Merger and Acquisition among Heterogeneous Polluting Firms: Theory and Evidence

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Abstract

The paper examines the role of environmental policy in affecting the incentive of polluting firms to engage in mergers and acquisitions (M&As). With endogenous and exogenous policies, we find a negative relationship between the profitability of a merger and emission tax. Even though aggregate figures suggest that M&As in highly polluting sectors take a significant share of total mergers, we show that firm heterogeneity plays a central role in explaining M&As. The empirical and theoretical result shows that mergers are more common among highly polluting firms within a given sector whereas at the sector level less polluting sectors tend to have a higher incidence of M&As. The empirical result supports a flexible policy regime in which governments strategically change policies after a merger takes place.

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I Introduction

The study addresses two research questions: Do polluting firms have a higher tendency to merge as compared to less polluting firms? Do environmental policies affect the incentive of polluting firms to merge? To start with the first question, historically, Mergers and Acquisitions (M&As) in highly polluting sectors have had a significant share in the total value and number of M&As. For instance, during 2009/2010 in Europe the value of mergers in pollution-intensive sectors identified by Hettige et al. (1995) accounted for about 80% of the value of deals and 81% of the volume of deals in the secondary sector. In 2010, M&As in pollution-intensive sectors accounted for about 31% of the total value of all deals in all sectors in Europe. Another example is the USA in 2009 where among the top industries with the highest M&A deal volume, M&A in polluting sectors accounted for over 55% of the total value of deals.

During 1996-2006 the value of cross-border M&A activities in the top 20 pollution-intensive sectors accounted for, on average, 53% of the total value of deals in the secondary sector. For most of these years, the annual value of deals in the top 20 polluting sectors was higher than less polluting sectors (see Figure 1) and the gap seems to be growing in the years 2004-2006.[1] On average, the chemical sector appears to account for about 42% of the value of merger deals in the top 20 polluting sectors during 1996-2006 (all values are calculated by author based on FactSet (2010), UNCTAD data and Hettige et al. (1995)).

[1] Based on Hettige et al. (1995) ranking of pollution-intensive sectors, out of the top 20 polluting sectors the following were engaged in cross-border M&As during 1996-2006: chemicals, textile, leather, printing and publishing, rubber and plastic, wood, metal, non-metallic mineral products, oil and gas and petroleum refining.

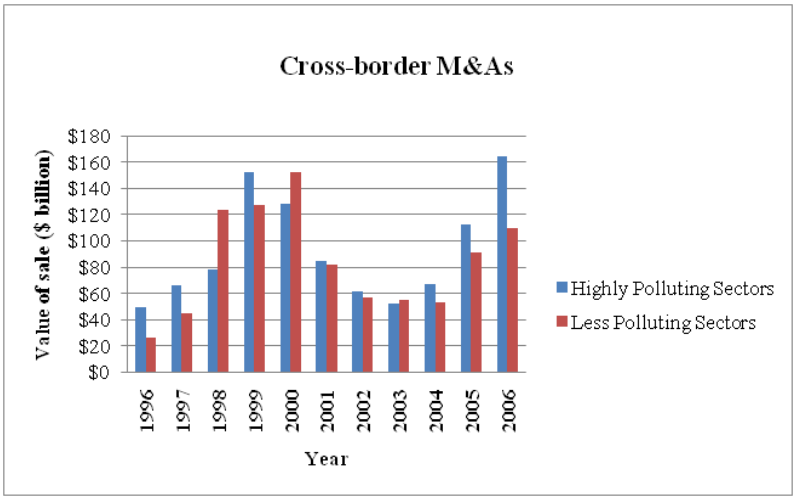

Figure 1: Annual value of cross-border M&A

This empirical regularity based on aggregate values seems to suggest that M&As in highly polluting sectors take a significant share of total mergers. Are M&As more common in highly polluting sectors than less polluting sectors as the data suggests (the between-sectors effect)? Or could it be highly polluting firms *within* a sector which merge more than less polluting firms in the same sector (the with-in a sector effect)? In this paper we show that the aggregate figures could be misleading and that firm heterogeneity has a role in affecting merger decisions. Using data from European manufacturing facilities we find that firms engaged in M&As are highly polluting and have a lower relative abatement compared to independent firms in the same sector. Furthermore, in addition to firm heterogeneity which explains the 'within a sector effect', we test for the 'between-sectors effect' and examine whether variation across sectors with respect to pollution intensity affects merger decisions. Contrary to the empirical regularity indicated in Figure 1, the empirical analysis shows that less polluting sectors have a higher frequency of mergers than highly polluting sectors. This may be due to the lower regulation and lower environmental cost incurred by less polluting sectors.

We introduce a flexible environmental policy where optimal environmental policy is a function of the market structure (Katsoulacos and Xepapadeas, 1996). The government sets weaker environmental regulation for industries with few local firms where such regulations increase as the number of firms increases. This is because weaker environmental regulations increase the competitiveness of domestic firms relative to foreign firms (Barrett, 1994b). We find that when a merger takes place the market structure changes followed by an endogenous decline in the optimal environmental policy which in turn increases the incentive to merge. M&As in sectors with environmental externalities can affect environmental policies and this can be illustrated by the recent merger between two energy companies, Northeast Utilities (NU) and NStar, forming the largest utility provider in New England. The size and scale of the merger is expected to allow the firm to "play a large role in New England energy policy and national energy policy". There are concerns that NU/NStar will have a large voice in debates around the recently proposed cap-and-trade mechanism and standards for renewable energy use (Platts, 2010; Kahn, 2010).

Using a flexible policy regime, we show that highly polluting firms in a given sector have the highest incentive to merge. On the contrary, in a fixed policy regime merged entities have a relatively lower pollution intensity as compared to independent firms in the same sector. The empirical finding seems to support a flexible policy regime in which countries formulate environmental policy by taking into account the market structure. The test for the exogeniety of environmental policy indicates that such policies may be endogenous to the market structre.

The second research question addresses the role of environmental policies in affecting the incentive to merge. Previous studies have established that firms have the incentive to engage in M&As as long as there is sufficient asymmetry in marginal cost (Farrell and Shapiro, 1990; Levin, 1990; Barros, 1998; Fauli-Oller, 2002; Collie, 2003; Qiu and Zhou, 2007). This is because the merged entity can always shift production

from the high-cost plant to the low-cost plant without changing total output. In this paper, in addition to cost asymmetries we will study whether and how environmental policies affect the incentive to merge using a flexible policy regime, a fixed policy regime and an empirical approach.

The role of environmental policy in affecting business transactions, capital allocation decisions and M&A strategies has gained significant importance with the growing political and public concern for climate change issues. Gehsmann and McCeney (2009) argue that firms planning to make an acquisition should investigate the effect of environmental policy on those businesses they wish to acquire. This is because M&A deals may be initiated when firms seek tax credits by merging with producers engaged in off-setting activities such as energy-efficient programs. In addition, with a cap-and-trade system firms which exceed their limits may wish to acquire efficient firms to gain more emission rights. Furthermore, merger decisions are affected by expected future changes in environmental policy. For instance, following the announcement of the European Union to penalize car producers based on carbon emission effective 2012, high-emission Porsche acquired low-emission Volkswagen line in 2008. The acquisition would allow Porsche to rely on Volkswagen's efficient technological capabilities as well as save costs by avoiding to pay penalties estimated to about $517 million annually. Another example is the acquisition of CNX Gas Corporation by coal and gas producer CONSOL Energy in 2008. The acquisition is an effort to decrease coal and increase gas in the energy portfolio due to the anticipation that regulation on gas will increase to a lesser extent as compared to regulation on coal (Gehsmann and McCeney, 2009). Hence, environmental policy has a role in affecting merger decisions.

The theoritical result indicates that in a flexible policy regime, the endogenous decline in emission tax increases the incentive to merge. Similarily, in a fixed policy regime, where emission tax is exogenously given, a decrease in emission tax increases

the incentive to merge. In the empirical section we present results from an endogenous and exogenous model were both results support the theoretical findings. That is, a lower emission tax increases the probability that a firm engages in a merger or acquisition.

The results obtained from this study have important policy implications. So far antitrust and industrial policies are determined independently from environmental policies. Some M&As which may not be allowed by the anti-trust agency might actually be welfare improving if environmental conditions are taken into account. On the contrary, some M&As, even if profitable for the participant firms may not be environmentally friendly. However, if environmental policies create incentives for merger as is argued in this study, then environmental policy makers have a role in affecting the market structure; and hence environmental policies should be harmonized with anti-trust policies in order to maximize social welfare and reduce gross pollution. In addition, if highly-polluting firms have a significantly higher probability to merge as compared to less polluting firms in a given sector, then anti-trust agencies should incorporate environmental aspects when accepting or rejecting merger proposals. Furthermore, this study provides an introduction to integrating the 'theory of M&A' and the 'theory of pollution'.

In the next section, we introduce a model of profit maximizing firms in a Cournot Oligopoly competition where asymmetries are introduced in terms of pollution intensity and abatement technology. In section III we start with the second research question and examine the potential role of environmental policy in affecting the incentive to merge. The incentive to merge is studied under a flexible and a fixed policy regime. Section IV endogenizes the merger decision to determine which of the firms, i.e. highly polluting or less polluting firms, actually engage in M&A at equilibrium. We derive the optimal merge in a flexible and fixed policy regime. In section V we present an empirical test for the major theoretical predictions and finally section VI

concludes the discussion.

II The Model

There are three firms engaged in the production of a homogenous good and competing in a Cournot Oligopoly market. Assume the economy is closed and all resources are fully employed.[2] The demand for the good is linear and downward sloping as follows

$$p = a - X \ where \ X = X_1 + X_2 + X_3 \tag{1}$$

where $a > 0$, X_i is the output of firm i, $i = 1, 2, 3$, and X is the market demand. Similar to Salant et al. (1983) firms have identical marginal cost of production, c. Since marginal costs are assumed to be constant, a non-monopoly forming merger is followed by shutting down all plants except one where the merged entity operates. All firms use an end-of-the-pipe-type abatement technology as in Lahiri and Symeonidis (2007) where initially production takes place producing gross pollution out of which the firm abates a certain amount while the rest is emitted. Each firm pays a per unit emission tax, t , for each unit of pollution it fails to abate. The firms incur cost of abating pollution, where the abatement cost function is assumed to be quadratic as in Barrett (1994a).

$$g(A_i) = \frac{r_i A_i^2}{2} \ where \ \ g'(A_i) > 0, \ r > 0 \tag{2}$$

$$A_i = \theta(X_i) - e_i \tag{3}$$

$$\theta(X_i) = Z_i X_i \ , where \ \theta(0) = 0, \ Z > 0 \tag{4}$$

[2] The major results of the model are unchanged for any finite number of firms. In addition, the assumption of unemployment does not alter the main results.

where $g(A_i)$ is the abatement cost of firm i, A_i is the abatement level of each firm i, r_i is an efficiency parameter of the abatement technology, $\theta(X_i)$ is gross pollution, Z_i is the pollution intensity of firms and e_i is the emission level of each firm i. We assume $Z_1 > Z_2 > Z_3$ and $r_1 > r_2 > r_3$ where the firms can be ranked according to efficiency in abatement and pollution intensity.

In the above model there are two types of distortions: oligopoly distortion where there is less competition and pollution distortion where there is disutility from emission. Environmental policies such as an emission tax are primarily designed to reduce the level of emission. On the other hand, the government would also like to reduce oligopoly distortion by charging a consumption tax. Following Keen and Lahiri (1993), the consumption tax is assumed to be a specific tax, T, and the producer's price is re-defined as the consumer price less the consumption tax as follows

$$P = p - T \tag{5}$$

where P is the producer's price and p is the consumer price.

Each firm i maximizes profit with respect to output and emission level as follows

$$\max_{X_i,\, e_i} \ \pi_i = (P - c)X_i - \frac{r_i A_i^2}{2} - te_i \ , \ where \ i = 1, 2, 3 \tag{6}$$

Any two firms can decide to merge but merging to form a monopoly is prohibited as outlined by the European Commission Merger Guidelines and the US Merger Guidelines provided by the Department of Justice and the Federal Trade Commission (which is an enforcement of Section 7 of Clayton Act, 1914). A non-monopoly forming merger changes the market structure from a triopoly to a duopoly. Initially, the

three independent firms maximize independent profit to produce $X_i = (a - c - T + t\sum_{i=1}^{3} Z_i)/4 - tZ_i$ where $i = 1, 2, 3$ and the consumer price is $p = (a+3c+3T+t\sum_{i=1}^{3} Z_i)/4$.

Suppose firm 1 and 2 decide to merge,[3] then it is reasonable for the merged entity to use the most efficient abatement technology which belongs to firm 2. The merged entity (m) and firm 3 (the outsider, hence the subscript 'o') maximize respectively

$$\pi_{1,2}^{m} = (P_m - c)X_m - \frac{r_2 A_m^2}{2} - te_m \tag{7}$$

$$\pi_{3,o} = (P_m - c)X_{3,o} - \frac{r_3 A_{3,o}^2}{2} - te_{3,o} \tag{8}$$

where P_m is the producer's price in a duopoly. market. The first order conditions yield $p_m = (a+2c+2T+t\sum_{i=2}^{3} Z_i)/3$ where $p_m > p$ and $X_m = (a-c-T-2tZ_2+tZ_3)/3$, $X_{3,0} = (a-c-T-2tZ_3+tZ_2)/3$. As in Salant et al. (1983) we find that the merged entity produces lower than the sum of the independent firms, $X_1 + X_2 > X_m$.

Firm 1 and 2 merge only if the merged entity's profit is greater than the sum of the independent profits. Hence, the profitability of such a merger is defined as

$$\Delta = \pi_{1,2}^{m*} - \pi_1^* - \pi_2^* \tag{9}$$

where * indicates a value at equilibrium. Similarly, Salant et al. (1983) argued that Δ represents the increase in joint profit when firms collude.

Policy instruments such as an emission tax and consumption tax are not arbitrarily set, rather they are optimally chosen by maximizing a social welfare function. Welfare in the country is defined as the sum of consumer surplus, profits, revenue collected

[3] The basic results are unchanged when firms 2 and 3 merge or when firms 1 and 3 merge.

from emission tax and consumption tax less disutility from emission.

$$W = \frac{1}{2}X^2 + \sum_{i=1}^{n} \pi_i + TX + (t - \psi) \sum_{i=1}^{n} e_i \tag{10}$$

where $n = 3$ in a triopoly market and $n = 2$ in a duopoly. market after a merger takes place. The marginal disutility of emission, ψ, is assumed to be constant and positive (results are unchanged with non-linear marginal disutility function).

III Incentives to Merge: The role of environmental policy

Farrell and Shapiro (1990), Levin (1990), Fauli-Oller (2002) and Qiu and Zhou (2007) assume that asymmetry among firms is due to marginal cost of production where a merger can be profitable as long as there is sufficient heterogeneity in marginal costs. The asymmetries introduced in this study are in terms of pollution intensity (Z_i) and efficiency of abatement technology (r_i). Firm i's effective marginal cost can be expressed as $C_i = c + tZ_i + T$ where $C_1 > C_2 > C_3$.

We study the incentives to merge in two types of policy regimes: a flexible policy regime where policy instruments are optimal at all times and a fixed policy regime where policy instruments are initially optimal but remain fixed thereafter. In a flexible policy regime we compare the pre- and post-merger policies to see if tax adjustment increases the profitability of a merger. In the fixed policy regime, we will examine the effect of an exogenous change in emission tax on the profitability of a merger.

III.1 Flexible policy regime

In a flexible policy regime, policies are endogenous and adjust to changes in the market structure. Katsoulacos and Xepapadeas (1996) and Barrett (1994b) argue that

environmental regulations are endogenous to market structure and that the government reduces regulation for industries with few local firms in order to give them a competitive advantage. Following this we consider the case where the optimal emission tax changes when the market structure changes due to a merger. We maximize welfare to solve for optimal policies before any merger takes place

$$t^* = \psi + \frac{2}{3}(\sum_{i=1}^{3} Z_i^2 - \sum_{i \neq j}^{3} Z_i Z_j) / \sum_{i=1}^{3}(1/r_i) \tag{11}$$

$$T^* = \frac{1}{9}\{-(3a - 3c - \psi \sum_{i=1}^{3} Z_i) - 2\sum_{i=1}^{3} Z_i \, [\sum_{i=1}^{3} Z_i^2 - \sum_{i \neq j}^{3} Z_i Z_j] / \sum_{i=1}^{3}(1/r_i)\} \tag{12}$$

The optimal emission tax is positive and primarily used to reduce emission. For all positive output we find $T^* < 0$ which implies that the government subsidizes consumption in order to reduce oligopoly distortion of "too little" consumption.

When firms 1 and 2 merge the market structure changes from a triopoly to a duopoly. followed by a change in the optimal policies

$$t_m^* = \psi \frac{0.5(Z_2 - Z_3)^2 + \sum_{i=2}^{3}(1/r_i)}{2(Z_3^2 + Z_2^2 - Z_3 Z_2)/3 + \sum_{i=2}^{3}(1/r_i)} \tag{13}$$

$$T_m^* = \frac{1}{4}\{-(2a - 2c - 3\psi \sum_{i=2}^{3} Z_i) - 2t_m^* \sum_{i=2}^{3} Z_i\} \tag{14}$$

Similar to the triopoly market, the optimal emission tax post-merger is positive and primarily used to reduce emission. By comparing the pre- and post-merger policies one can check that $t^* > t_m^*$ for all positive output.[4] It is optimal to charge a

[4] Similar to Conard (1996) the optimal emission tax is different from the Pigovian tax. The pre-merger tax is higher while the post-merger tax is lower than the Pigovian tax. A Pigovian tax can be obtained by charging each firm according to its pollution intensity and efficiency of abatement technology (for example t_1, t_2 and t_3).

lower emission tax post-merger than pre-merger because the gross pollution is lower, i.e. $\theta(X_m)+\theta(X_{3,0}) < \theta(X_1)+\theta(X_2)+\theta(X_3)$. Thus, firms in the duopoly. market (the merged entity and the outsider) enjoy a lower emission tax incentive as compared to independent firms in a triopoly market. This may make the proposed merger a profitable one.

The optimal consumption tax post-merger is actually a consumption subsidy which is used to reduce oligopoly distortion created by higher prices. After the merger takes place, the oligopoly distortion is higher than the pre-merger case and thus the optimal consumption subsidy post-merger should be higher than the pre-merger subsidy. Accordingly, we find $|T_m^*| > |T^*|$. The government gives a higher consumption subsidy for the merged entity which may serve as a possible incentive to merge.

Using the optimal policies post-merger and pre-merger we find that $\Delta > 0$ for all $a > \hat{a} + 18\sqrt{B^2 - A/9}$ where:

$$\hat{a} = 4t^*(2Z_3 - Z_1 - Z_2) + 9t_m^*(Z_2 - Z_3) + 22\psi(Z_2 + Z_3)/12 - 8\psi Z_1/3 + c > 0 > 0;$$

$$B = -c/18 + t_m^*/2(Z_3 - Z_2) - 11\psi(Z_3 + Z_2)/108 + 4\psi Z_1/27 + 2t^*(Z_2 + Z_1 - 2Z_3)/9;$$

$$A = -c^2/36 - c/3\{3t_m^*/2(Z_3 - Z_2) + \psi/9[4Z_1 - 11(Z_2 + Z_3)/4] - 2t/3[2Z_3 - Z_1 - Z_2]\} - 1/9\{1.5t_m^*(Z_3 - Z_2) - 0.75\psi(Z_3 + Z_2)\}^2 + 0.5t_m^*/r_2 - 0.5t^*(1/r_1 + 1/r_2) - 1/16\{[4/3t(Z_2 + Z_3 - 2Z_1) - 4/9\psi \sum_{i=1}^{3} Z_i]^2 + [4/3t(Z_2 + Z_1 - 2Z_3) - 4/9\psi \sum_{i=1}^{3} Z_i]^2\}$$

This condition shows that the proposed merger is profitable as long as the market size is sufficiently large. The sources of profitability and incentives to merge are two: lower tax incentives post-merger and cost savings due to rationalization of production. We should note that while a higher subsidy post-merger could be a potential source of incentives to merge, what is really driving the result is not the higher subsidy. If we assume $T = 0$ and solve for the optimal emission tax we still get $t^* > t_m^*$ and $\Delta > 0$ as long as the good has sufficient demand. Thus, polluting

firms merge in anticipation of a lower emission tax and cost saving. Gehsmann and McCeney (2009) argue that despite the difficulty in trying to fully anticipate changes in environmental regulation, firms should incorporate possible changes in regulation in their business deals including M&A decisions. For example, one reason for the recent lack of recovery of M&A activities in the oil and gas sector in the USA could be the impact of the new US energy regulation and the proposed cap-and-trade which makes valuation difficult (Energy M&A Forum, 2009). In addition, KPMG (2010) projects an increase in acquisition of North American cars by Asian automotive industry as a result of growing regulation and emission standard in North America. A good example is the attempt of GM motors to sell Hummer to Chinese Sichuan Tengzhong Heavy Industrial Machinery Corp in 2009. According to KPMG (2010) government incentives such as grants and loans for environmental friendly technologies are also expected to influence transactions in the USA and China. Furthermore, some mergers and acquisitions can influence environmental policy in their favor. This is illustrated by the growing concern that the merger between Northeast Utilities and NStar would affect energy policies in New England.

The result of this section can be summarized into the following proposition

Proposition 1 *In a flexible policy regime, when a merger takes place the optimal emission tax declines increasing the incentive to merge and firms engage in M&As in anticipation of a change in environmental policy.*

Unlike non-polluting firm, when a merger occurs among polluting firms, the resulting rationalization of production is not only in terms of a shift from a high-cost plant to a low-cost firm, but also a shift of production from a high-polluting plant to a less-polluting plant. That is, the gains from merging are not only limited to efficiency but extend to environmental gains.

III.2 Fixed policy regime

In this section we examine whether without the lower tax incentive of the flexible policy regime, cost savings from rationalization of production are sufficient to produce profitable mergers. We assume that emission tax and consumption tax are fixed at the initial optimal level (t^* and T^*). The profitability of a merger between firm 1 and 2 can be expressed as

$$\Delta = (p^m - p)^2 + 2(p - C_2)\{p^m + C_1 + \frac{3}{2}(C_2 - p)\} - (C_2 - C_1)^2 - \frac{t^2}{2r_1} \tag{15}$$

where $\Delta > 0$ as long as $|C_1 - C_2|$ and $|p^m - p|$ are sufficiently large. Consistent with the M&A literature we find that the proposed merger is profitable as long as there is sufficient heterogeneity among firms in terms of Z_i. This implies that efficiency gain and rationalization of production will result in a profitable merger, even without lower tax incentives. However, we find that a decrease in emission tax caused by an external shock increases the profitability of a merger.

Proposition 2 *If emission tax does not adjust to changes in the market structure, then a small decrease in emission tax increases the profitability of a merger.*

Proof. *The profitability of a merger between firm 1 and 2 is a quadratic function of t, where t is optimally chosen but not flexible to changes in the market structure;*

$$\begin{aligned}\Delta(t) = (a - c - T - 2tZ_2 + tZ_3)^2/9 - (a - c - T - 3tZ_1 + \sum_{i=2,3} tZ_i)^2/16 \\ - (a - c - T - 3tZ_2 + \sum_{i=1,3} tZ_i)^2/16 \end{aligned} \tag{16}$$

One can easily show that the second order condition with respect to emission tax is negative, $\Delta''(t) < 0$ *and that* $\Delta(t)$ *has a global maximum at* $\hat{t} = \{-(a-c-T)(9Z_1 - 5Z_2 - Z_3)\}/36\Delta''(t)$ *where* $\hat{t} > 0$ *and* $\Delta(\hat{t}) > 0$. *From the second order condition we know that* $d\Delta/dt < 0$ *for all* $t > \hat{t}$. *Given the government charges* t^* *for all possible market structures we find that* $t^* > \hat{t}$ *for all positive output. This implies that* $d\Delta/dt < 0$ *around* t^*. *A small increase (decrease) in emission tax decreases (increases) the profitability of a merger.* ■

Results from both the flexible and fixed policy regime suggest that an endogenous or exogenous decrease in emission tax increases the profitability of M&As among heterogenous polluting firms. This underlines the role of environmental policy in affecting merger decisions.

IV The Optimal M&A in Two Policy Regimes

In this section we endogenize the merger decision in both policy regimes to find which of the three firms have the highest incentive to merge at equilibrium. Acquiring firms offer a bid to acquire other firms in the same industry. Firms who get the offer (targets) can choose to either accept or reject the offer. If the offer is accepted the merger is formed, otherwise the firms exist independently and no merger is formed (Kamien and Zang, 1990; Gaudet and Salant, 1992; Rodrigues, 2001; Barros, 1998; Horn and Persson, 2001; Fridolfsson and Stennek, 2005a,b).

Following Qiu and Zhou (2007) we assume that only inefficient firms can be acquired by firms with a better efficiency. We consider the case where firm 2 and 3 are potential buyers of firm 1 where firm 3 is also a potential buyer of firm 2. The game is a simultaneous one-shot game where firm 2 posts a bidding price for firm 1 as well as an ask price to sell its ownership to firm 3. Firm 1 simultaneously sets its reservation price which is equal to its independent profit in the pre-merger market. Firms play

a two stage game and only one merger takes place. In the first stage targets accept or reject a merger proposal and in the second stage merger participants share their technology and produce à la Cournot. Targets compare prices and accept the highest bid if and only if the offer is greater than their reservation price. Acquiring firms ensure that their bids are not too high so as to make their net profits post-merger negative. In addition, an acquirer mergers with a partner which allows the highest profitability of a merger.

In Section III, we showed that all possible mergers are profitable due to rationalization of production and tax incentives ($\Delta > 0$). Hence, the potential buyers, firms 2 and 3, are willing to form a merger with their target by acquiring it. The maximum offer that a buyer j can give to a target i is can be expressed as

$$O_{j,i} = \pi_{j,i}^{m*} - \pi_j^* \tag{17}$$

where $O_{j,i}$ is the maximum possible offer that buyer j would give to its target i. The acquiring firms are willing to offer as much as but not greater than the difference between the profit earned as a merged entity and what they would earn as independent firms.

IV.1 Flexible policy regime

In the flexible policy regime, all profits are evaluated using optimal policies in the respective markets. That is, we use t^* and T^* to evaluate independent profits (π_i^*) and t_m^* and T_m^* to evaluate profit of the merged entity ($\pi_{j,i}^{m*}$).

Proposition 3 *The optimal merger is the one among the highly polluting firms where firm 2 acquires firm 1. The merged entity is highly polluting as compared to indepen-*

dent firms in the same sector.

Proof. *Inserting the appropriate optimal profits in equation (*17*) yields* $O_{3,1} < O_{2,1}$*, therefore firm 1 will accept firm 2's offer but reject firm 3's offer. Firm 1 is better-off by accepting 2's offer than earning independent profit since* $O_{2,1} > \pi_1^*$*. As long as firm 2's actual offer is slightly higher than* $O_{3,1}$ *firm 1 will accept it since* $O_{3,1} > \pi_1^*$*. Firm 2 is better-off merging with firm 1 as compared to earning independent profit since* $\pi_{1,2}^{m*}-$ *actual offer* $> \pi_2^*$*, where* $O_{3,1} <$ *actual offer* $< O_{2,1}$*. Even if firm* 3 *offers to buy firm* 2*, such an offer is not acceptable since firm* 2*'s net profit after merging with firm* 1 *is higher than the maximum offer that firm* 3 *can give to* 2*. That is,* $\pi_{1,2}^{m*}-$ *actual offer* $> O_{3,2}$*. Thus, the optimal merger is the one between firm 1 and firm 2.* ■

Thus, *within* a given sector, it is those firms with the highest abatement expenditure and the highest pollution intensity which have the highest probability of merging. This is because, in addition to cost saving from rationalization of production, highly-polluting firms receive the highest tax incentive. The post-merger tax when firm 1 and 2 merge is lower than (equal to) the tax when firm 2 and 3 merge (firm 1 and 3 merge) for all positive output and given $\Delta > 0$. Thus, in the post-merger market the merged entity has a higher pollution intensity than the independent firm ($Z_2 > Z_3$ and $r_2 > r_3$).

IV.2 Fixed policy regime

When optimal policies are fixed at t^* and T^* we find that $O_{3,1} > O_{2,1} > \pi_1^*$. As long as firm 3's actual offer is higher than $O_{2,1}$ firm 1 will accept 3's offer but reject 2's offer. Firm 3 is better-off after making the acquisition since $\pi_{1,3}^{m*}-$ actual offer $> \pi_3^*$, where $O_{2,1} <$ actual offer $< O_{3,1}$. But would firm 3 prefer to merge with firm 2 instead of firm 1? This is not optimal since the profitability of a merger between firm

3 and 1 is higher than the merger between firm 3 and 2. Specifically we find that $\Delta^{1,3} > \Delta^{2,3}$. This is because with fixed policies the most asymmetric firms gain the highest cost savings from rationalization of production. Thus, the optimal merger is the one between firm 1 and firm 3.

The result from the fixed policy regime can be summarized in a proposition as follows.

Proposition 4 *In the post-merger market the merged entity has the most efficient abatement technology as well as the least pollution intensity as compared to independent firms.*

In the next section we present an empirical analysis to test the two major theoretical predictions: the role of emission tax in affecting incentives to merge and a comparison of whether firms engaged in M&As have a higher or lower pollution intensity relative to independent firms. In addition, we will examine the 'between sectors' effect.

V M&As in Europe: Empirical test

In this section we present an empirical test for the two hypotheses derived in the theoretical model. The first hypothesis tests the negative relationship between emission tax and the profitability of a merger (Propositions 1 & 2) and the second hypothesis tests whether highly-polluting firms, with high r and high Z, have a higher probability of merging relative to less polluting firms in the same sector (Propositions 3 & 4). In addition to the above two hypotheses, we test whether pollution-intensive sectors have a higher tendency to merge as compared to sectors with low pollution intensity. This will distinguish the between-sectors effect from the within a sector effect.

Following the theoretical model, firms with high r and high Z also have a low relative abatement. The relative abatement of each firm i is expressed as the ratio of abatement to gross pollution as follows

$$\frac{A_i}{A_i + e_i} = f(Z_i, r_i) = 4t[Z_i r_i(a - c + t\sum_{i=1}^{3} Z_i - 4tZ_i)]^{-1} \tag{18}$$

A simple comparative statics shows that

$$\frac{\partial f(Z_i, r_i)}{\partial Z_i} < 0 \text{ and } \frac{\partial f(Z_i, r_i)}{\partial r_i} < 0 \tag{19}$$

Thus, the relative abatement of a firm can be used as a proxy for both its r and Z; and the second hypothesis is equivalent to testing whether firms with low relative abatement are more likely to engage in M&As than firms with high relative abatement.

The hypotheses are tested using a cross sectional data of over 7,000 manufacturing firms operating in 27 European countries. We use a Probit model where the dependent variable is a dummy variable which equals to one for firms engaged in a merger or acquisition and zero for independent stand-alone firms.

$$\Pr(merger_i = 1) = \Phi(a_0 + a_1 f + a_2 t + a_3 t * f + a_4 t^2 + a_5 H + a_6 \mathbf{Q} + \epsilon_i) \tag{20}$$

where $\Pr(merger_i = 1)$ is the probability that firm i is engaged in a merger or an acquisition, $\Phi(.)$ is the cdf of a normal distribution, t is emission tax, f is relative abatement and is used to control for asymmetries among firms in Z_i and r_i, H is the pollution intensity of sectors and is used to identify the *between-sectors* effect, $\mathbf{Q}$ is

a vector of other non-environmental determinants of M&As and ϵ_i is the error term.

We include a quadratic form of tax as an explanatory variable following Proposition 2 where we found that $\Delta(t)$ is quadratic in t and $\Delta''(t) < 0$. Furthermore, we include an interaction term between relative abatement and emission tax because abatement is relatively more important when there is a higher emission tax. That is, when firms are charged a higher emission tax they will have more incentives to adopt and use abatement technologies (Frondel et al., 2004).

The marginal effects of emission tax and relative abatement are calculated as follows

$$\frac{\partial \Pr(merger_i = 1)}{\partial t} = (a_2 + a_3 f + 2a_4 t)\Phi'(.) \tag{21}$$

$$\frac{\partial \Pr(merger_i = 1)}{\partial f} = (a_1 + a_3 t)\Phi'(.) \tag{22}$$

where $\Phi'(.)$ is the probability density function of a normal distribution.

In the following subsections we present the data sources and discuss the procedure used to normalize the data. Before presenting the estimation results the firms in the sample will be characterized using descriptive statistics.

V.1 Data issues and source

A list of European manufacturing firms engaged in mergers or acquisitions is obtained from the European Commission Directorate General of Competition (EC-DGC). When two or more independent firms merge into one entity or if one firm takes a controlling ownership of another by purchasing assets or shares it should notify the European Commission (EC). The EC examines all proposed mergers which involve firms with a combined worldwide turnover of 5,000 million Euro or a combined turnover of 250 million Euro or more within the EU. The EC approves those

merger proposals which do not significantly impede competition in the EU (EC, 2004b). We include merger cases notified to the EC during 1990-2010. The study considers only horizontal mergers in the manufacturing sector where the merger participants have atleast one production activity in common. The EC-DGC reports a total of 4,553 merger cases during 1990-2010 out of which 1,951 cases involve firms in the manufacturing sector. Most cases report a merger or acquisition notification involving two firms, however there are some cases involving up to 4 firms. About 92% of the merger cases received final approval from the EC after 1995.

Firm level emission and abatement data is obtained from the European Pollutant Release and Transfer Register (E-PRTR). The E-PRTR was adopted by the European parliament and the EU Council in 2006 in order to increase public participation in environmental matters and the right to access environmentally related information. Firms engaged in activities which typically release pollutants harmful for human health and the environment are required to report emission and abatement data to the national authority of their country which transfers the information to the EC which makes the information publicly available (www.prtr.ec.europa.eu). A total of 24,000 facilities engaged in the energy sector, production and processing of metals, mineral industry, chemical industry, waste and waste water management, paper and wood production and processing, livestock and aquaculture, animal and vegetable products as food and beverage have reported their data. Facilities are required to report if their production capacity is greater than a given annual threshold specific to each activity. This study is based on those firms engaged in the manufacturing sector.

The E-PRTR reports emission and abatement data for about 7,867 manufacturing firms operating in 27 European countries. Each firm i reports the actual emission of pollutants it releases to water, air and land annually in kilograms/year if the emission

level is in excess of a given annual threshold (EC, 2006a).[5] Consistent to the theory, firms report abatement levels based on end-of-the-pipe-type technologies. Two types of end-of-the-pipe-type technologies are reported: off-site transfer of pollutants in waste water for treatment and off-site transfer of solid wastes for disposal or recovery. Off-site transfer of pollutants in waste water refers to the 'movement of waste water beyond the boundaries of the firm (through pipes etc.) for the purpose of physical, chemical or biological treatment'; and off-site transfer of solid waste refers to the 'movement of waste beyond the boundaries of the firm for disposal (incineration, decomposition etc.) or recovery' (recycling, regeneration etc.) (EC, 2006b).

The EC-DGC merger data is matched with the E-PRTR data based on the name of the parent company, NACE sector code and country of operation. When a match is found the firm is considered as a polluting firm engaged in a merger or acquisition, whereas the rest of the unmatched firms in the E-PRTR are treated as independent firms not involved in M&As.

There are two major market based instruments used in Europe in order to reduce environmental pollution and depletion of natural resources; environmental taxes/charges and tradeable permits. The EU trading system started operation in 2005 and it is too early to evaluate its success. On the other hand, the use of environmental taxes and charges gained significant importance in Europe since the mid 1990s where several countries developed comprehensive pollution charges. Even though rates were lower in the earlier years, evidence on their effectiveness in terms of providing incentives for abatement measures is broadly positive (EEA, 2005). It would be appropriate to use emission tax to test the first hypothesis since a majority of the mergers in the manufacturing sector in Europe took place after 1995 which is a period where emission taxes were gaining importance in environmental policy.

[5] Pollutants are classified into 7 groups: chlorinated organic substances, inorganic substances, other organic substances, heavy metals, pesticides, greenhouse gases and other gases.

Emission tax rates are obtained from two sources: the OECD/European Environmental Agency (EEA) and Eurostat. The OECD/EEA provides a specific tax on country-sector level which is directly used for all available countries and sectors. Emission tax is reported in Euro per kilogram (or Euro per ton) of the major pollutant released or waste disposed by the production sector. For the rest of the observations where we were not able to find a specific tax (about 290 observations) we calculated the emission tax using environmental tax revenue and value of output obtained from Eurostat and pollution intensity obtained from Hettige et al. (1995) as follows

$$t_{j,k} = \frac{(t_{j,k})(E_{j,k})}{VALUE_{j,k}} . \frac{1}{P_j} \tag{23}$$

$$P_j = \frac{E_{j,k}}{VALUE_{j,k}}, \text{ for country } k \tag{24}$$

where $E_{j,k}$ is the emission level from sector j in country k in pounds, $t_{j,k}$ is the country-sector specific emission tax rate in dollar per pound, $(t_{j,k})(E_{j,k})$ is environmental tax revenue from sector j in country k in dollars, $VALUE_{j,k}$ is the value of output of sector j in million dollars and P_j is the pollution intensity of sector j reported in pound per million dollar. All weights are converted to kilograms and all values to dollars using the average monthly Euro-Dollar exchange rate in 2007.[6] The pollution intensity of sectors obtained from Hettige et al. (1995) is used as explanatory variable to test the between-sectors effect and identify if highly polluting sectors tend to merge more than less polluting sectors.

Vector **Q** contains country-sector specific non-environmental variables used to explain what drives M&As based on previous literatures. For instance, Jovanovic and Rousseau (2001) and Martynova and Renneboog (2006) showed that the increase in M&A activities in most advanced economies is mainly attributed to technological

[6] Same results are obtained while using the end of the year exchange rate.

innovations and the 1990s merger wave in Europe appears to cluster in high tech sectors. To control for sectors with high technological progress we use the R&D intensity of sectors. R&D intensity of a sector is calculated as the ratio of R&D expenditure in the sector to the value of output in that sector. Value of output and R&D expenditure are obtained from Eurostat.

Rossi and Volpin (2004) argued that M&A activities are strong in countries with better investor protection laws and Giovanni (2005) showed that M&As flow to countries with stronger financial markets. To control for countries with better investor protection we use the investment risk index given by the International Country Risk Guide (ICRG). The index ranges from 0 to 12; 0 for high risk countries and 12 for low risk countries. The investment risk refers to contract viability, payment delays and difficulty in profit repatriation. To control for countries with better financial markets we use the ratio of the value of financial assets in a country to its total GDP. Table 1 provides a summary of variables used in the study along with their reported units and sources.

Table 1: Data source and definition

Description	**Reported unit***	**Source**
Value of output: sector j, country k	million Euro	Eurostat
R&D expenditure of private firms: sector j, country k	million Euro	Eurostat
Investment risk index of country k	0-high risk, 12-low risk	ICRG
Financial asset of non-financial firms	% of GDP	Eurostat
Firms engaged in M&A: 1990-2010	-	EC-DGC
Pollution intensity of sector j	pound per million dollars	Hettige et al. (1995)
Emission tax: sector j, country k	Euro per kilogram	OECD/EEA
Total environmental tax revenue: sector j, country k	thousand Euro	Eurostat
Off-site transfer of pollutants in waste water for treatment	kilogram/year	E-PRTR
Off-site transfer of solid waste for disposal & recovery	ton/year	E-PRTR
Release of pollutant to air and water	kilogram per year	E-PRTR
Euro-Dollar exchange rate 2007	average of 12 months	Eurostat
R&D intensity: R&D expenditure/value of output	%	constructed

*All weights are converted to kilograms and all values to dollars in the analysis.

V.2 Normalization procedure

The actual emission of each firm as reported in the E-PRTR does not represent the effective emission of firms and thus cannot be used to compare firms. This is because some pollutants (e.g. Mercury, Cadium, Arsenic compounds, DDT, etc.) are more harmful as compared to the same weight of other pollutants (e.g. Carbondioxide, Chlorine, etc.). Irabien et al. (2009) proposed a normalization process in which the emission level of each pollutant is divided by its respective reporting threshold. This is because highly toxic pollutants have a lower threshold as compared to less toxic pollutants. However, Irabien et al.'s (2009) measure does not tell us by how much the firm has exceeded its allowed threshold. In this paper we propose a measure of effective emission which allows comparison of firms based on how much more than the threshold they emitted. If each firm i emits q different pollutants, the effective emission of the firm is computed as $e_i = \sum_{p=1}^{q}(a_{p,i} - T_p)/T_p$ where $a_{p,i}$ is the release of pollutant p by firm i in kilogram/year, T_p is the given reporting threshold for each pollutant p in kilogram/year and e_i is a unit free measure of effective emission of firm i.

Using a similar argument we normalize and aggregate abatement levels obtained from off-site transfer of pollutants in waste water for treatment and the off-site trans-

fer of solid waste for disposal or recovery. The sum of the two normalized off-site transfers represent how much beyond the threshold the firm has succeeded to abate using end-of-the-pipe-type techniques. The normalized emission and abatement are used to calculate relative abatement and rank firms as highly-polluting or less polluting.

V.3 Description of the data

A total of 7,867 manufacturing firms engaged in 203 different activities have reported their abatement and emission levels to the E-PRTR where about 23% have been engaged in M&As approved by the EC. None of these mergers are monopoly forming since The Commission rejects merger proposals which 'reduce competitiveness by creating a dominant player' with a market share of 25% or higher in any part of the common market (EC, 2004b).

The firms are engaged in activities which typically release pollutants harmful for human health and the environment where about 60% of them operate in the largest EU Member States namely Germany, France, Italy and UK. The highest absolute number of M&A cases also comes from these countries. Table 2 gives a distribution of the manufacturing firms by country of operation. Countries like Austria, Belgium, Netherlands and Sweden also have a higher percentage of their firms engaged in M&As.

Table 2: Distribution of polluting firms by country of operation

Country	**Total firms**	**% Firms**	**Firms in M&A**	**% M&A**
Austria	79	1.00	29	36.7
Belgium	317	4.03	96	30.3
Bulgaria	40	0.51	1	2.5
Cyprus	5	0.06	2	40.0
Czech Rep.	212	2.69	34	16.0
Denmark	144	1.83	28	19.4
Estonia	25	0.32	6	24
Finland	173	2.20	64	37
France	1,345	17.10	321	23.9
Germany	1,729	21.98	367	21.2
Greece	62	0.79	14	22.6
Hungary	87	1.11	18	20.7
Italy	668	8.49	105	15.7
Liechtenstein	1	0.01	0	0.0
Lithuania	20	0.25	3	15.0
Luxembourg	11	0.14	3	27.3
Malta	3	0.04	0	0.0
Netherlands	246	3.13	86	35.0
Norway	44	0.56	17	38.6
Poland	320	4.07	45	14.1
Portugal	210	2.67	36	17.1
Romania	69	0.88	4	5.8
Slovakia	91	1.16	19	20.9
Slovenia	88	1.12	8	9.1
Spain	771	9.80	144	18.7
Sweden	175	2.22	67	38.3
UK	932	11.85	309	33.2
TOTAL	7,867	100	1831	23.2

In addition to a country distribution, the sample of firms can further be classified by activities using the NACE sector and sub-sector codes. About 40% of the firms are engaged in the production and processing of metals, chemicals, paper products, iron and steel, plastic, dairies and cheese making and pharmaceutical products. When M&A deals are grouped by sector, firms engaged in M&A tend to cluster in sectors such as chemicals, plastic, paper, motor vehicles and its parts, pharmaceuticals, iron and steel, cement, aluminium and refined petroleum products both in absolute and relative terms (see Table 3). Most of these sectors are usually considered to be

technology intensive (Damiani and Pompei, 2008).

Table 3: Sector distribution, 2007

	Total firms		**Firms in M&A**	
Sectors	Number	%	Number	%
Treatment & coating of metals	1,065	13.54	93	8.7
Organic basic chemicals	380	4.83	124	32.9
Paper and paperboard	278	3.53	86	30.9
Chemical products	215	2.73	56	26
Basic iron, steel & ferro-alloys	201	2.55	52	25.9
Plastic in primary form	200	2.54	85	42.5
Casting of iron	191	2.43	26	13.6
Dairies and cheese making	182	2.31	31	17
Pharmaceutical products	181	2.30	36	19.9
Inorganic basic chemicals	181	2.30	47	26
Meat products	174	2.21	14	8
Aluminium	122	1.55	38	31.1
Cement	97	1.23	35	36.1
Parts of motor vehicles	95	1.21	41	43.2
Refined petroleum products	92	1.17	34	37
Motor vehicle	75	0.95	41	43.2

Table 4 gives a distribution of firms according to the type(s) of abatement technology used and the effective emission level. About 96% of the firms use at least one type of abatement technology while the remaining 4% have a positive level of emission but no reported abatement. A zero reported abatement does not necessarily mean that the firm did not abate at all, it only indicates that the actual abatement level is lower than the reporting threshold. A majority of these 4% are independent

firms with no M&A activities during 1990-2010. About 97% of the firms engaged in M&A have at least one form of abatement technology and about 67.5% of them succeeded to achieve a zero emission level. Another interesting observation is that about 74% of all firms with at least one type of end-of-the-pipe abatement technology have succeeded in achieving a zero emission level. In Table 4(c) one can see that firms engaged in M&As have on average 6 times higher emission and 3 times higher abatement as compared to independent firms.

Table 4: Emission and abatement

(4a.) Number of firms with abatement and emission

Abatement	Positive		Zero	
Emission	M&A	Independent	M&A	Independent
Positive	573	1,148	59	262
Zero	1,194	4,631	0	0

(4b.) Forms of end-of-the-pipe-type technology	With	Without
Off-site transfer of pollutant in waste water for treatment	1,283	6,584
Off-site transfer of solid waste for disposal or recovery	7,253	614
Both forms of abatement technologies	990	321

(4c.) Effective abatement and effective emission

M&A	Obs.	Mean	Independent	Obs.	Mean
Emission	1,826	33,345	Emission	6,041	5,121
Abatement	1,826	360,087	Abatement	6,041	96,734

A descriptive statistics of the variables used in the estimation is presented in Table 5a. All variables have a reasonable degree of variation except the investment risk index. All countries in the sample have investment risk index between 9 and 12 and the average investment risk is very close to the maximum. The correlation between the M&A dummy and emission tax is negative as predicted in Propositions

1 and 2. Similarly, we have a negative correlation between the M&A dummy and relative abatement. On the other hand, as Table 5b shows the correlation with R&D intensity, financial assets and investment risk are positive.

Table 5: Descriptive statistics and correlation matrix

(5a) Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Effective abatement	7,867	157,860	3,545,868	0	291 m
Effective emission	7,867	11,672	395,390	0	30.4 m
Emission tax ($/ kg)	6,178	6.99	9.77	0	22.2
Pollution intensity	7,865	11.35	14.53	0.22	105.3
Value of output (million)	5,242	85,075	70,108	0.548	428,583
Relative abatement	7,867	0.915	0.246	0	1
R&D intensity (%)	2,608	0.98	1.59	0	12.9
Investment risk index	7,866	11.81	0.41	9	12
Financial asset (%)	6,703	106.41	37.99	28.7	183.1

(5b) Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)
1. M&A firms	1.00					
2. Relative abatement	−0.0208	1.00				
3. Emission tax	−0.0157	0.2029	1.00			
4. Pollution intensity	−0.054	0.1729	0.2212	1.00		
5. R&D intensity	0.1519	0.0282	0.1	−0.1163	1.00	
6. Investment risk	0.0421	0.0706	0.645	0.1885	0.1234	1.00
7. Financial asset	0.0324	−0.078	−0.1931	−0.5249	0.1965	−0.1441

V.4 Empirical results

The estimation result from the Probit model, marginal effects and exogeneity test results are presented in Table 6. The dependent variable is a dichotomous variable indicating whether the facilities are independent firms or merged entities. Model (a) uses only emission tax as the explanatory variable, model (b) includes the relative abatement of firms to control for firm heterogeneity and model (c) controls for country risk and technological progress. We add the pollution intensity of sectors in model (d) to control for the between-sectors effect. Marginal effects are reported for model (d). Model (e) and (f) control for the value of output and the financial strength of the country respectively. Finally model (g) presents results from an instrumental variable approach where we control for the endogeneity of emission tax.

Following the theoretical result, there are two sources of endogeneity; reverse causation where changes in the market structure affect the emission tax and the endogeneity of emission tax since the optimal emission tax is a function of Z_i and r_i. We test for endogeneity using the Blundell-Smith exogeneity test (Smith and Blundell, 1986) and proceed to use the efficient estimation method proposed by Amemiya (1978) and Newey (1987). The value of output in each sector and country dummies are used as instrumental variables.

First of all, concerning the possible effect of emission tax on incentives to merge, the empirical result is consistent with the flexible and fixed policy regimes. We find evidence that higher emission tax significantly and negatively affects the probability that a firm engages in M&As. In addition, consistent with Proposition 2, the coefficient on the quadratic term of emission tax is significant and negative except in the instrumental variable estimation. This suggests that there may be a non-linear relationship between emission tax and firms' decision to engage in M&As.

Secondly, we find that firms with a lower relative abatement have a significantly

higher probability of merging. This shows that firm heterogeneity with respect to pollution intensity plays a significant role in merger decisions. Merged entities have a relatively higher pollution intensity and inefficient abatement technology as compared to independent firms and this result supports the flexible policy regime. In an empirical study, Ederington and Minier (2003) examine two factors as to why governments endogenously adjust environmental policies: to make domestic firms internationally competitive and in exchange for the political support of firms with influential market power. They use data from US manufacturing firms to show that as industries become more and more concentrated, firms are more likely to have a stronger lobby and hence face a relatively lower environmental regulation. Using data from 33 countries during 1982-1992, Cole et al. (2006) show that a change in market structure caused by entry of foreign firms leads to a change in environmental regulation. In a similar spirit, the empirical result obtained in this study supports a flexible policy regime and implies that the actual emission tax depends on the market structure. Governments may strategically change environmental regulations after a significant change in the market structure and countries may formulate environmental policy by taking the market structure into account . Historically there were instances where policy makers have adjusted national policies in response to a change in the market structure caused by a merger or acquisition. For example, the British government imposed a new windfall profit tax in 1997 following the privatization of utility companies through foreign acquisitions. Similarly, the takeover of the Swedish Volvo by FORD in 1999 was followed by an additional profit tax.

Furthermore, at the sector level, sectors with lower pollution intensity have a higher tendency to engage in M&A as compared to sectors with higher pollution intensity. This implies that the aggregate figures presented in the introduction section can be quite misleading without sufficient analysis. It is not the case that highly polluting sectors have a higher tendency to merge, rather the empirical and theo-

retical result shows that within a given sector highly polluting firms tend to engage in M&As more frequently. To illustrate the result consider two sectors: food producers and pharmaceuticals. Hettige et al (1995) ranks pharmaceuticals as highly polluting as compared to food producers. Our result suggests that food producers are more likely to engage in M&As as compared to drug producers. However, among food producers those with the highest pollution intensity have more tendency to merge than non-polluting food producers. Similarly, variation among drug producers in terms of pollution intensity affects the decision of individual firms to engage in M&As. Hence, this provides a clear distinction between the 'with-in a sector effect' and 'between-sectors effect'.

In addition to the environmental variables, R&D intensity has a highly significant and positive effect on the probability of merging. Consistent with previous studies, firms in a high-tech sector have a higher probability of restructuring through M&As. Investment risk is also an important determinant of mergers as firms in countries with a lower investment risk have a higher probability of merging. However, we find no evidence that neither the value of output nor the financial strength of a country can affect the probability of M&As among polluting firms in Europe. A robustness check with country dummies shows that only the Germany dummy has a significantly positive coefficient while the rest of the results remain intact.

Table 6: Regression results of Probit Model

Dependent variable: Pr($Merger_i = 1$), dy/dx is marginal effect								
	(a)	**(b)**	**(c)**	**(d)**	**dy/dx**	**(e)**	**(f)**	**(g)**
Emission tax	-0.0082^a	-0.0079^a	-0.0285^a	-0.0281^a	-0.1988^a	-0.0254^b	-0.0343^a	-0.0579^c
	(0.0018)	(0.0018)	(0.0114)	(0.0115)		(0.0122)	(0.0125)	(0.0325)
Relative abatement		-0.1276^c	-1.1255^a	-1.1686^a	-0.0174^a	-1.1520^a	-1.1805^a	-1.1682^a
		(0.0737)	(0.2971)	(0.2985)		(0.2992)	(0.3476)	(0.2983)
Investment risk			0.3516	0.3508^a	0.0988^a	0.3574^a	0.3752^a	0.4929^a
			0.1239^a	(0.1237)		(0.1238)	(0.1311)	(0.1901)
R&D intensity			9.1022^a	10.0927^a	2.8434^b	10.2784^a	11.6261^a	9.7668^a
			(1.7494)	(1.8181)		(1.9071)	(2.0746)	(1.8542)
Pollution intensity				-0.0051^b	-0.0014^b	-0.0051^b	-0.0143^b	-0.0048^b
				(0.0025)		(0.0025)	(0.0076)	(0.0025)
Interaction term*			0.1522^a	0.1582^a	–	0.1571^a	0.1664^a	0.16448^a
			(0.0415)	(0.0417)		(0.0417)	(0.0469)	(0.0420)
(Emission tax)^2			-0.0561^a	-0.05879^a	–	-0.0598^a	-0.05364^b	-0.0278
			(0.0244)	(0.0245)		(0.0245)	(0.0275)	(0.0403)
Value of output						-0.018		
						(0.7290)		
Financial asset							−0.0008	
							(0.0009)	
Constant	-0.6511^a	-0.5356^a	-3.5394^a	-3.4489^a		-3.3826^a	-3.5103^a	-4.7137^a
	(-0.6511)	(0.0699)	(1.4094)	(1.4081)		(1.4107)	(1.4930)	(1.9037)
Obs.	6,178	6,178	2,063	2,063	2,063	2,063	1,823	2,063
Smith-Blundell test of exogeneity for emission tax: 5.5281 Chi-qr(1), P-value = 0.0187								

^{a}denotes significance at 1%, ^{b}denotes significance at 5%, ^{c}denotes significance at 8%

*Interaction term between emission tax and relative abatement

VI Conclusion

This paper examines two issues: the role of environmental policies in affecting incentives to merge and a comparison of whether highly polluting firms merge more as compared to their less polluting counterparts. In a flexible policy regime, environmental policies endogenously change with the market structure and when a merger takes place the optimal emission tax declines. This lower tax incentive is favorable for a proposed merger. In a fixed policy regime, policies are given but an exogenous decrease in emission tax increases the profitability of a merger. Our empirical result supports both policy regimes where we show that as emission tax declines the probability that a merger takes place increases, even with endogenous policy. This implies that though the primary target of environmental policies is to reduce pollution, such policies may have an external and unanticipated effects on the market structure by influencing firm's decision to engage in M&As.

Furthermore, we have shown that firm heterogeneity plays a significant role in explaining M&As. In a flexible policy regime highly-polluting firms have the highest incentives to merge whereas in a fixed policy regime the results are quite the opposite. The empirical result supports the flexible policy regime suggesting that governments

may strategically adjust environmental policies based on the market structure. At the sector level, however, contrary to what the raw facts reveal, less polluting sectors have a higher probability of merging than highly polluting sectors.

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