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The Effect of Environmental Consciousness on Emission Tax and Abatement Equipment*

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Abstract

This paper investigates the effect of environmental consciousness on firms' adoption decisions toward a pollution abatement equipment. The impact of environmental awareness takes a form of cost reduction, which turns the interaction among firms into a coordination game with multiple equilibria: either both firms adopt or no one adopts. This is contrary to the various facts of partially coordination on pollution control. Moreover, two prominent criteria for equilibrium selection suggest that the equilibrium with no adoption should be chosen. We provide a solution by proving the existence of collusion outcomes in subgames following asymmetric adoption decisions. Such a subgame outcome, in turn, supports the asymmetric adoptions (partially coordination) as part of a subgame perfect equilibrium.

JEL classification: Q28, H21, C61, C79.

Keywords: emission tax, environmental consciousness, equilibrium selection, coordination

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1 Introduction

Until recent years, it is realized that humans are precipitating a current wave of mass destruction to the nature. Approximately "27,000 species a year, which boils down to three species an hour, are lost forever" (Eldredge 1998). Overpopulation, overexploitation, and the failure to recognize the connections between ecosystems have been accused for the main reasons for such destruction. More and more individuals or organizations hence urge for the development of **environmental consciousness**, the attention to overlooked aspects of plants, animals, the natural routine and the human impact, as part of social responsibility (Eldredge 1998).

Although it seems promising to promote such social responsibility, a rigorous analysis is necessary for a thorough picture of its effects on individuals as well as government policies. The closest concept in the existing literature is to introduce *social norm*, which is put forth by Akerlof (1980). Akerlof described the idea that there exists a code of behavior (i.e., social norm) in the community and those who disobey the code will be punished by a *loss* of reputation in the community. More specifically, take for instance that the authorities use an emissions tax to motivate oligopoly firms to adopt pollution abatement equipment at a fixed rent F. Similar analyses on this subject can be found in Damania (1996), Downing and White (1986) and Milliman and Prince (1989). The existence of environmental responsibility here will create an emotion that, when there are more firms adopting the abatement equipment, each firm feels more obliged to adopt too. That is, in Akerlof (1980)'s terminology, adopting the equipment not only reduces each firm's physical cost from tax, but also creates a *gain* toward adoption.

Following the social norm literature (see also Elster (1989)), we present such a gain for complying with social obligation by a cost reducing function, which is multiple to the fixed rent F and is decreasing in the numbers of adopters. Such a cost reduction only occurs when the other firms also adopt. To make it nontrivial, we assume that F is sufficiently high such that a single firm will not adopt if no other firms adopt. Consequently, the adoption decisions among firms become one of coordination games, where it is well known that there are two coordinated equilibria: either all firms adopt, or no one adopts.

There have been two different approaches proposed in the literature for equilibrium selection: the first is to introduce private information, by Carlsson and van Damme (1993), and the second is to introduce random mutation in the evolutionary process, by Kandori, et. al (1993). In a two by two (strategies) game, both approaches will select the risk dominant equilibrium. A risk dominant equilibrium is the equilibrium associated with the largest product of deviation losses. Unfortunately, the risk dominant equilibrium in this model is the one associated with no adoption!

Before jumping into our resolution to such embarrassment, it is important to look at the reality. The following three examples describe cases where individuals are aware of their environmental damage, but they are only *partially coordinated*. First, the Kyoto Protocol is an agreement, signed by 39 industrialized nations in 1997, to cut emissions of six greenhouse gases to an average of 5.2 percent below 1990 levels by the period 2008-2012. But the Protocol will not take effect until it is ratified by 55 percent of the nations, and worse of all, USA pulled out in 2001. Second, although the dumping of radioactive wastes (from ships, aircraft and other man-made structures) at sea is prohibited by the OSPAR Convention, announced at the annual meeting in Copenhagen on June 29, 2000, the UK and France continue dumping, despite strong evidence of environmental damage. Third, despite of a moratorium on whale hunting imposed in 1986, it is calculated that Japan and Norway kill 1,000 whales every year for commercial purposes. Even worse, the Japanese and Norwegian hunters are now turning their attention towards the dolphins- cousins, the whales.

The analytical result suggests that, with the presence of environmental consciousness, no firms will adopt the abatement equipment (selected by both criteria), but the empirical evidence shows that people will be at least partially coordinated on pollution control. We quote Damania (1996)'s result in this journal to provide a strategic dimension to look at such a difference. Damania considered an infinitely repeated framework, where the production lasts forever after firms' tax\adoption decisions at the outset. He then characterized the conditions under which all firms would rather not to adopt cost saving equipment, in order to maintain cooperation benefits in the long term. The key point is that, *if the coordination in production is optional, firms' coordination in production can influence firms' tax\adoption decisions, and vice versa.* Here, since we consider a static game, allowing cooperation in production does not make any difference if firms coordinate on their adoption decisions. With identical costs, the benefits from unilateral deviation will dominate, and all firms end up with competition. However, if firms do not coordinate on adoption, there can be situations where cooperation can sustain, which in turn, justify the existence of a partial adoption equilibrium in the first stage.

In this paper, we consider a static game with environmental consciousness, where two firms make their tax\adoption decisions simultaneously, and then decide whether to cooperate in production. The introduction of environmental obligation creates a cost saving effect if both firms can coordinate on adoption. Thus, given that no cooperation can be sustained in static games, firms' adoption decisions become one of coordination games, where in equilibrium either all firms adopt, or none of them adopt. Neither of the equilibria matches perfectly with the reality, and worse of all, the equilibrium with no adoption will be selected by two prominent approaches in equilibrium selection.

To interpret such an tension between analytical result and the reality, we reconsider the possibility of collusion in static games. Our result suggests that under certain conditions, there exists a subgame perfect equilibrium, where firms will cooperate in the continuing games following the asymmetric adoption decisions, and this in turn upsets the realization of coordinated equilibria. In this case, firms will not deviate from cooperation, because the cooperation benefit and cost saving from equally sharing the adoption cost will outbeat the unilateral benefit from deviation.

Our setting is a static version of Damania (1996)'s supergame framework. While Damania focused on cooperation supported by trigger strategies, we investigate if cooperation can be supported in a static subgame. Such an equilibrium does not occur in Damania's setting because asymmetric adoptions are not considered in his setting. However, we look at asymmetric adoptions mainly to check the effect of environmental consciousness, which is not addressed by Damania. Downing and White (1986) and Milliman and Prince (1989) also examine the effect of emission tax on firms' incentive to adopt a pollution abatement equipment, but they considered a monopoly or perfect competition structure, where coordination is impossible or difficult.

The rest of paper is organized as follows. Section 2 sets up the model with environmental consciousness, in which duopolistic firms face their adoption\tax and then production decisions. In Section 3, we present results for the effect of environmental consciousness on firms' adoption and production decisions. Some comparative statics on emission tax, the size of gain for complying with such consciousness, and the size of firms are provided here. Section 4 concludes our paper.

2 The Model

Consider an industry with two identical firms, producing a homogenous product. The market is described by a downward sloping linear demand function, with a sufficient large scale: $P = a - bQ$ with $0 < Q < A$. To simplify, it is assumed that all firms are equipped with the same production technology: a linear production cost cq_i with $c > 0$. During the production process, pollution is produced and we denote it by a linear damage function zq_i, where $z > 0$.

It is assumed that government authorities attempt to control each firm's pollution below a desired level z^*, by charging an emission tax on extra damage. The tax scheme T is defined by

$$T = \begin{cases} \tau(zq_i - z^*), & \text{if } zq_i > z^*, \\ 0 & \text{if } zq_i < z^*, \end{cases}$$

where, without loss of generality, assume that $z^* = 0$. In other words, each firm faces two sources of costs: the production cost (c) and the pollution cost (τz). The latter cost, however, can be eliminated by adopting a pollution abatement equipment at a cost of F per period.

Employing an abatement equipment will not only decrease each firm's physical cost, but also stimulate the others' moral consciousness toward environmental protection. When there are more firms participating in pollution control, each firm feels more obliged to take the effort for pollution control. Such environmental consciousness is captured by the concept of *social norm*, put forth by Akerlof (1980). Therefore, following the literature on social norm, we assume a multiple term $g(n)$ to the adoption cost, where n denotes the number of other firms that also adopt the equipment and $g(n) \leq 1$ indicates the *gain* for complying with the social norm. In our duopoly model, the adoption cost hence becomes $g(0)F$ if there is no other adopter, and $g(1)F$ if the rival also adopts. To simplify, it is assumed that $g(0) = 1$ and $g(1) < g(0)$.

We consider the following timing of game: two firms firstly chooses whether to adopt such an abatement equipment, then given their adoption decisions, they decide whether to cooperate in production, simultaneously. The second stage game is standard in microeconomics texts: if both firms cooperate, they pursuit the maximal joint profit, which is then equally shared by firms; if only one firm deviates from cooperation, the non-deviating firm sticks to the output associated with cooperation, while the deviating firm pursuits its maximal profit, given its opponent's output. The difference between our setting and Damania's (1996) is, that the present model is a static game, while Damania's framework is one of infinitely repeated games. Our focus is on the situation where, due to the prevalence of environmental consciousness, cooperation can possibly be maintained in a static game.

The game is solved backward. Denote by A the decision of "adopting the equipment" and N for "not adopting". Given various combinations of adoption decisions, indicated by the pairs (k, l), $k, l = A, N$, we calculate each firm's profits for various combinations of cooperation decisions. Denote each firm's profits by $\pi_i^{xy}(k, l)$, where $i = 1, 2$ and $x, y = C, D$. The superscripts denote firm 1 and firm 2's choices on "to cooperate (C) or not (D)", respectively, given their adoption decisions of $k, l = A, N$. The calculation is standard and provided as follows. Notice that since the adoption cost does not affect marginal profits, and hence is not included in the calculation of $\pi_i^{xy}(k, l)$.

Firstly, if both firms compete in production, each firm pursuits it's own maximal profit. That is, for each possible pair of k and l, with $k, l = A, N$,

$$\pi_i^{DD}(k, l) \equiv \max_{q_i}[a - bq_1 - bq_2 - c_i]q_i, \text{ where } c_i = \begin{cases} c, & \text{if } i = A \\ c + \tau z, & \text{if } i = N. \end{cases}$$

The equilibrium outputs q_i^{DD}, $i = 1, 2$ vary with their adoption decisions. If firm i adopts the abatement device, the pollution cost is eliminated and hence the marginal cost term is only c; while if firm i has not adopted the device, the pollution cost is included and hence $c_i = c + \tau z$. That is, $q_i^{DD} = \frac{1}{3b}(a\text{-}2c_i + c_j)$, where $c_i, c_j = \begin{cases} c, & \text{if } i, j = A \\ c + \tau z, & \text{if } i, j = N. \end{cases}$, and $\pi_i^{DD}(k, l) = \frac{1}{9b}(a\text{-}2c_i + c_j)^2$.

Secondly, if both firms cooperate and there is at least one adopter, then they equally share the equipment and the maximal joint profit, that is,

$$\pi_i^{CC}(k, l) \equiv \frac{1}{2}\max_q[a\text{-}bq\text{-}c_i]q, \text{ where } c_i = \begin{cases} c, & \text{if } (k, l) = AA, AN, NA \\ c + \tau z, & \text{if } (k, l) = NN. \end{cases}$$

The equilibrium output $q^{CC}(k,l)$ is the same for each firm, but varies with their adoption decisions. In particular, $q^{CC}(k,l) = \frac{1}{4b}(a-c)$,if $(k,l) = AA, AN, NA$, and $q^{CC}(k,l) = \frac{1}{4b}(a-c-\tau z)$ if $(k,l) = NN$. The maximal profit is $\pi_i^{CC}(k,l) = 2b(q^{CC}(k,l))^2$.

Lastly, in the case of unilateral deviation from cooperation, due to the symmetry assumption, we have $\pi_1^{DC}(k,l) = \pi_2^{CD}(k,l)$ and $\pi_2^{DC}(k,l) = \pi_1^{CD}(k,l)$ for each possible pair $k,l = A, N$. Given the non-deviating firm follows the output as $q^{CC}(k,l)$, the maximal deviation profit is defined as follows.

$$\pi_1^{DC}(k,l){=}\pi_2^{CD}(k,l) \equiv \max_{q_i}[a\text{-}bq^{CC}(k,l)\text{-}bq_i\text{-}c_i]q_i, \text{ where } c_i{=}\begin{cases} c, & \text{if } i{=}A \\ c{+}\tau z, & \text{if } i{=}N. \end{cases}$$

The respective outputs and profits for the deviator are $q_1^{DC}(k,l){=}q_2^{CD}(k,l){=}\frac{1}{2b}(a- bq^{CC}(k,l)-c_i)$ and $\pi_1^{DC}(k,l){=}\ \pi_2^{CD}(k,l){=}\frac{1}{64b}(3a+c(k,l)-4c_i)^2$, where $c(k,l) = c$ if $(k,l) = AA, AN, NA$, and $c(k,l) = c+\tau z$ for otherwise. The profits for the non-deviating firm are hence

$$\pi_2^{DC}(k,l) = \pi_1^{CD}(k,l) \equiv [a - bq^{CC}(k,l) - bq_2^{CD}(k,l) - c_i]q^{CC}(k,l),$$

which is $\frac{1}{32b}(3a{+}c(k,l)\text{-}4c_i)(a\text{-}c(k,l))$, with $c_i{=}\begin{cases} c, & \text{if } i{=}A \\ c{+}\tau z, & \text{if } i{=}N. \end{cases}$

In the first stage, given the cooperation decisions (x,y), with $x,y = C,D$ by firm 1 and firm 2, respectively, in the continuing games, each firm i faces a two by two payoff matrix, consisting of $\pi_i^{xy}(k,l)$ for various combination of adoption decisions, including $(k,l){=}\ (A,A),(A,N),(N,A)$ and (N,N). The equilibrium concept is "subgame perfect equilibrium", which requires rational choices be taken in all subgames. Finally, we look at equilibria in pure strategies only, and leave the discussion of mixed strategy equilibrium in the concluding remarks.

3 Results

Firstly, some preliminary results are summarized in the following lemma concerning the relative sizes of $\pi_i^{xy}(k,l)$ in the continuing games.

Lemma 1 *(1) For* $(k,l)=(A,A)$ *or* (N,N), $\pi_1^{Dy}(k,l)>\pi_1^{Cy}(k,l)$ *for* $y=C,D$, *and* $\pi_2^{xD}(k,l)>\pi_2^{xC}(k,l)$ *for* $x=C,D$. *(2) For* $(k,l)=(A,N)$ *or* (N,A), $\pi_1^{CC}(k,l)=\pi_2^{CC}(k,l)$. *(3)* $\pi_2^{CD}(N,A)=\pi_1^{DC}(A,N)$, *and* $\pi_1^{CD}(N,A)=\pi_2^{DC}(A,N)$.

The first point says that if both firms have coordinated on adoption, then deviating from cooperation is a strictly dominant strategy in the continuing game. This implies that the subgame following (A,A) or (N,N) is one of the prisoner dilemma games, a traditional structure for oligopoly, and the only equilibrium in these subgames is to deviate simultaneously: (D,D). The second point in the lemma says that when both firms cooperate, they will equally share the abatement equipment and the maximal joint profit. The last point comes from the assumption of symmetry among firms.

To have a non-trivial analysis, we make the following assumptions concerning the effect of environmental consciousness on adoption costs. For otherwise, we have two obvious conclusions: F could either be too high or too low. In the former case, firms never adopt even in the presence of cost reduction stimulated by social obligation; while in the latter, they will adopt right away.

Assumption $\pi_1^{DC}(A,N)$-$\pi_1^{DC}(N,N)<F$ and $g(1)F<\pi_1^{DD}(A,A)$-$\pi_1^{DD}(N,A)$.

The assumptions for firm 2 are similarly defined. This assumption describes the effects of $g(1)$ on the adoption cost. When the fellow firm also adopts the equipment, there is a gain to join in the pollution control. This gain is so large such that, the original adoption cost would preclude adoption even if the rival is cooperating, but once the fellow firm also adopts, the pecuniary gain favours adoption even if the rival is competing. Notice that since $\pi_1^{DD}(A,N) > \pi_1^{DD}(A,A)$ and $\pi_1^{DC}(A,N)$-$\pi_1^{DC}(N,N)$> $\pi_1^{DD}(A,N)$- $\pi_1^{DD}(N,N)$, this assumption also implies that $\pi_1^{DD}(A,A)$-$\pi_1^{DD}(N,N) < F$. The first inequality denotes that the cost saving from adoption has a positive marginal effect, and the second inequality indicates that such marginal effect is higher, if the opponent can oblige to the cooperation output.

A textbook anticipation about collusion among firms is that, although cooperation is Pareto efficient, all firms end up competing with each other. Proposition 1 describes the first image we have for the effects of social consciousness.

Proposition 1 *If two firms compete in all continuing subgames, then there are two equilibria in the first stage: (A,A) and (N,N).*

Proof: To have the equilibria (A,A) and (N,N), two conditions must satisfy for firm one: $\pi_1^{DD}(A,A) - g(1)F \geq \pi_1^{DD}(N,A)$, and $\pi_1^{DD}(N,N) \geq \pi_1^{DD}(A,N) - F$. The conditions for firm two are similarly derived. These are satisfied under the Assumption, because $\pi_1^{DD}(A,N)$- $\pi_1^{DD}(N,N) < \pi_1^{DC}(A,N) - \pi_1^{DC}(N,N) < F$. □

The proof describes the conditions for the coordinated equilibria, which are satisfied under the Assumption. Here we take it as a presumption that collusion cannot sustain in a static game. But, as will be proved shortly, this is not the only conclusion for every range of parameters. Given such a presumption, the pecuniary *gain* for following the social norm has turned the individual adoption decisions into a coordination game. It is well known that there are two possible equilibria: either all firms adopt or no firm adopts. Neither of the equilibria can be ruled out without imposing further restrictions.

These restrictions include the introduction of private information, raised by Carlsson and van Damme (1993), and the introduction of random mutation in the evolutionary process, proposed by Kandori, et. al (1993). In our two by two (strategies) game, both approaches will select a risk dominant equilibrium (see

Carlsson and van Damme (1993) and Kandori, et. al (1993)). A risk dominant equilibrium is the equilibrium associated with the largest product of deviation losses. That is, we need to compare two products of deviation losses associated with (A,A) and (N,N), respectively: the product of [$\pi_1^{DD}(A, A)$-$g(1)F$-$\pi_1^{DD}(N, A)$] and [$\pi_2^{DD}(A, A)$-$g(1)F$- $\pi_2^{DD}(A, N)$], and the product of [$\pi_1^{DD}(N, N)$- $\pi_1^{DD}(A, N)$-F] and [$\pi_2^{DD}(N, N)$-$\pi_2^{DD}(N, A)$-F]. If the former is greater, then (A,A) is the risk dominant equilibrium; otherwise, (N,N) is the risk dominant equilibrium. It can be easily checked that $\pi_1^{DD}(A, A)$- $\pi_1^{DD}(N, A) < \pi_1^{DD}(A, N)$- $\pi_1^{DD}(N, N)$, meaning that the marginal benefit from adoption is higher if the rival has not adopted. Together with the same argument for firm two and because $\pi_1^{DD}(N, N)$-$\pi_1^{DD}(A, N)$ is negative, it is true that the product of deviation losses for (N, N) is higher than that of (A, A). That is, (N, N) is the equilibrium selected by both approaches!

Damania (1996)'s result in this journal provides us a leeway to such embarrassment. In a repeated game setting, he concluded that, under certain circumstances, firms will eschew a cost saving adoption of the abatement equipment, to ensure the cooperation benefit in the long run. Our focus is, that firms' coordination in production can influence firms' adoption decisions, and vice versa. This implies that in our model, cooperation might be able to exist for certain combinations of firms' adoption decisions. If competition is not the only outcome, then the equilibrium selection problem in the first stage can be avoided.

The following lemma shows the existence of a cooperative outcome in subgames following the decisions with only one adopter. In the proof, the existence conditions for cooperation are satisfied under the Assumption.

Lemma 2 *Two firms will compete when they simultaneously adopt or not adopt; while if there is only one adopter, there exists an equilibrium where both firms cooperate.*

Proof: The first part follows easily from part (1) of Lemma 1. Next, the necessary conditions for the existence of a cooperative equilibrium in the case of (A,N) are: $\pi_1^{CC}(A,N)$-$\frac{1}{2}F \geq \pi_1^{DC}(A,N)$-$F$ and $\pi_2^{CC}(A,N)$-$\frac{1}{2}F \geq \pi_2^{CD}(A,N)$. Substracting the first condition by the second gives $\pi_1^{DC}(A,N)$-$F \leq \pi_2^{CD}(A,N)$, which is always true because part (3) of Lemma 1, the fact that $\pi_2^{CD}(N,A)$-$\pi_2^{CD}(A,N) < \pi_2^{CD}(N,A)$-$\pi_2^{CD}(N,N)$, and the Assumption (for firm two) imply that $\pi_2^{CD}(N,A)$-$\pi_2^{CD}(A,N) < F$. The proof for the case of (N,A) is similar. □

Intuitively, in subgames following (A,N) and (N,A), the adopter will not deviate from cooperation, because the cost reduction by sharing adoption cost exceeds the gain from deviation. On the other hand, the non-adopter will not deviate either, because the cooperation and cost-saving benefits exceed the cost increase for not sharing adoption cost in deviation. This, however, will be true when the tax burden is not too heavy (so $\pi_2^{CD}(N,A)$-$\pi_2^{CD}(A,N)<F$). We can characterize various combinations of τ and F for such conditions to be satisfied. However, is cooperation more preferable such that the outcome with no adoption can be avoided? Proposition 2 describes the existence of asymmetric equilibrium in the first stage.

Proposition 2 *There exists an equilibrium with only one adopter in the first stage.*

Proof: Given Lemma 2, the conditions for the equilibrium (A,N) are $\pi_1^{CC}(A,N)-\frac{1}{2}F>\pi_1^{DD}(N,N)$ and $\pi_1^{CC}(N,A)-\frac{1}{2}F> \pi_1^{DD}(A,A)-g(1)F$. By part (2) of Lemma 1, substracting the first condition by the second gives $\pi_1^{DD}(A,A) - \pi_1^{DD}(N,N)$ $>\pi_1^{DD}(A,A)- \pi_1^{DD}(N,A)>g(1)F$. The proof for the equilibrium (N,A) is similar.□

Because of symmetry among firms, we have multiple equilibria again! But since these two equilibria are not Pareto comparable, no criterion can be adopted for equilibrium selection. The central point of Proposition 2 is, that coordination in production can possibly impede with the realization of coordination in adoption. This not only explains why there is only partially coordination in various cases we discussed above, but also helps avoid the embarrassment that the equilibrium with no adoption will be selected. However, this result is nevertheless contenting, unless we can ensure its robustness up to some variations to the specifics in the model.

It can be first checked that our results do not rely on the linearity of demand and cost functions, but different levels of emission tax, the *gain* for complying social norm, and different setup for the timing of game will cause some changes to the equilibrium.

First of all, if the deviating benefit is sufficiently high such that $\pi_1^{DC}(A, N)$-F>$\pi_1^{DC}(N, N)$, the cooperative equilibrium in subgames will disappear. Notice that the term $\pi_1^{DC}(A, N)$- $\pi_1^{DC}(N, N)$ will increase with the emission tax τ, as both the deviating benefit and cost saving will increase. There are hence two possible effects for increasing emission tax. First, if τ is not too high so that still $\pi_1^{DD}(A, N)$-F <$\pi_1^{DD}(N, N)$, then there will be multiple equilibria. Our analysis above selects the equilibrium with no adoption at all. Second, if τ is high enough to the extent that $\pi_1^{DD}(A, N)$-F >$\pi_1^{DD}(N, N)$, then the only static outcome is both firms adopt the device. Such a conclusion seems exciting: there is no actual tax distortion to production (since both adopt the equipment) and pollution is eliminated! However, the credibility of the authorities, including severe monitoring and exact execution of laws is critical to this result. As reported in Lebanonwire, June 8, 2002, corruption or other forms of lobbying is the real cause behind increased air pollution produced by the transport sector.

Secondly, it is interesting to see how education on environmental consciousness works in our model. Suppose that education increases the non-pecuniary *gain* for complying the social norm, i.e., $g(1)$ decreases. From the proof of Proposition 2, $\pi_1^{DD}(A, A)$-$g(1)F$ will increase, and this might upset the cooperative equilibrium in the subgame and hence the asymmetric equilibria in adoption games. However, this will not guarantee full adoption if τ is not too high (as in the first case from the above paragraph).

Finally, an increase in the number of firms will reduce the benefit from adoption (due to the equal sharing rule), and hence upset the cooperative equilibria in the subgame. However, if the order of decisions change to one with simultaneous decisions, then firms face a 4×4 game, each with a strategy set $\{AC, AD, NC, ND\}$. It can be checked that no adoption is still an equilibrium even with the presence of environmental consciousness.

4 Concluding Remarks

This paper investigates the effect of environmental consciousness on duopolistic firms' incentives to adopt a pollution abatement equipment. We consider a static version of Dimania (1996)'s setup, where make their adoption (of an abatement equipment) and then cooperation decisions sequentially. The impact of environmental awareness takes a form of cost reduction, which occurs only if the other firm also adopts. Therefore, given the presumption that collusion can not sustain in a static subgame, the interaction of firms' adoption decisions turns into a coordination game, in which there two equilibria: either both firms adopt or no one adopts. Neither of them matches perfectly with the realistic evidence of partial coordination. Worse of all, when we apply two prominent criteria proposed by Carlsson and van Damme (1993) and Kandori, et. al (1993), the risk dominant equilibrium, where no firm adopts, will be selected.

Our paper then characterizes the conditions, under which cooperation can occur in subgames following asymmetric adoption decisions. Such a subgame outcome, in turn, supports the asymmetric adoptions as part of subgame perfect equilibrium. This not only explains why there is only partially coordination in various cases, but also helps avoid the embarrassment that, with the presence of environmental consciousness, the equilibrium with no adoption will be selected.

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