Why Isn't the Accident Information Shared? A Coopetition Perspective[+]

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ABSTRACT (English)

The purpose of this article is to investigate both cooperative and competitive strategies of firms that may cause accidents. The firms may exchange information about the previous accidents associated with their products in order to reduce accident probabilities and the amount of damage. Thus, these firms may cooperate on this point. On the other hand, they compete on quantities after deciding whether accident information is to be disclosed. This situation is termed "coopetition."

In order to address the issue of disclosure of accident information, we develop an economic model and it derives two main conclusions. First, there is a unique equilibrium where firms choose to not disclose their accident information. Second, the equilibrium strategies of firms are Pareto inferior for them when the condition relating to marginal effort costs and potential demands is satisfied. Thus, whether the coopetitive situation that firms exchange their accident information cooperatively and choose their

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quantity levels competitively is desirable for firms depends on the magnitude of the cost reduction and demand reduction effects.

ABSTRACT (Spanish)

Este artículo investiga estrategías cooperativas y competitivas de las empresas que sufran accidentes. Las empresas se cambien las información sobre los accidentes anteriores relacionados a sus productos para reducir las probabilidades de accidentes y la cantidad de pérdida. Por eso, estas empresas cooperen en este punto. A propósito, ellas compitan por cantidades después de decidir si la información de accidentes se declaran. Esta situación se llaman "*coopetición*."

Para discutir el asunto de la declaración de la información de accidentes, desarrollamos un módelo económico y esto muestra dos concluciones principales. Primero, hay un equilibrio único donde las empresas elijan no declarar su información de accidentes. Segundo, la estrategia de equilibrio para las empresas son Pareto inferiores para ellas si la condición relacionada al esfuerzo marginal de los costos y de las demandas potentiales se satisface. Por lo tanto, si la situación *coopetitiva* que las empresas intercambien su información de accidente cooperativamente y eligen sus niveles de cantidad competivamente es deseable para las empresas depende del grado del efecto de la reducción de los costos y de la demanda.

INTRODUCTION

The use of past accident information is very important in preventing severe accidents such as death and serious illness. For example, automobile makers design and install safety features (child seat, air bag system) in response to the causes of past automobile accidents. Thus, if the firms could use accident information, they may be able to reduce the number of severe accidents.

From this view, sharing information with competitors creates more ideas on how to reduce accident probabilities and the amount of damage, because all firms have access to considerably more accident information. In other words, information sharing is an effective way of improving risk management.

However, in reality, each firm does not tend to disclose its accident information to competitors. There are several reasons for not disclosing accident information. First, disclosing accident information lowers demand. For example, some Japanese consumers avoided buying US beef after reports that it contained dangerous elements associated with mad cow disease. In this case, they purchased beef from domestic producers or imported beef from countries other than the USA, or used other meats (pork and chicken) and fish. Second, disclosing accident information gives competitive advantages to their competitors. The firms that obtain accident information can lower not only effort costs for safety management but also costs for maintenance and compensation after sales. Thus, all firms want to receive accident information, but they do not want to give it out themselves. Using the terminology of microeconomic theory, competitors can be free riders regarding accident information. For example, Okura (2008) found that Japanese life insurance firms choose to withhold their information

even if disclosing information is a Pareto-superior strategy. Each life insurance firm wants to free ride and does not want its competitors to free ride on the basis of its information, and so there is a unique equilibrium of "not disclosing information." In summary, firms may be reluctant to disclose their accident information because information sharing adversely affects competition after the information disclosure.[1]

There is a large literature that examines the role of information in the market. For example, Vives (1984), Gal-Or (1985), Shapiro (1986), Sakai and Yamato (1989), and Liu and Serfes (2006) focused on Cournot and/or Bertrand competition with imperfect information about costs or demand, and they examined the firm's incentives to share information. Agrell, Lindroth, and Norrman (2004) and Chu and Lee (2006) studied information sharing in supply-chain management. There are also some literatures that examine the role of information in the field of coopetition studies. For example, Lado, Boyd, and Hanlon (1997) discussed cooperation and competition using the prisoners' dilemma story. Tsai (2002) considered knowledge sharing and its coordination mechanisms in intraorganizational networks. Camisón-Zornoza, Boronat-Navarro, and Villar-López (2008) studied alliances in terms of sharing their knowledge.

The purpose of this article is to investigate both the cooperative and competitive strategies of firms that may cause accidents. In order to reduce accident probabilities and the severity of damages, each firm attempts to improve the safety level of its products and these firms may exchange information about its previous accidents. Thus,

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[1] Of course, there are other reasons. For example, disclosing accident information may reveal a firm's private information. Consider the case where every automobile maker has particular car engine technologies. This technology may create an advantage over competitors and so firms are very careful to keep these technologies private. Thus, if there is some possibility that secret information will be revealed, automobile makers will choose to withhold their accident information to protect their competitive advantages.

these firms may cooperate in this regard. On the other hand, they compete on quantities, quality, prices, and so forth, after deciding whether accident information is to be disclosed. This situation, which contains both cooperation and competition, is called "coopetition" by some authors (for example, Brandenburger and Nalebuff, 1996; Padula and Dagnino, 2007). However, with the existence of the disadvantages of information sharing we referred to before, such coopetitive situation may not be realized voluntarily.

This article attempts to address the following three questions highlighted by the coopetition literature in relation to accident information. (1) Can this coopetitive situation arise voluntarily? (2) If a coopetitive situation is realized voluntarily, why isn't the accident information shared? (3) Is it desirable to realize the coopetitive situation by using some other mechanisms such as laws and institutions?

In order to answer the above three questions, we build an economic model with two firms facing the following three-stage game. In the first stage, both firms decide whether to disclose their accident information to their competitor. In the second stage, they choose their effort level for improving the safety level of their products. In the third stage, they choose their quantities.

The main conclusions derived by the economic model are as follows. First, there is a unique equilibrium where firms choose to not disclose their accident information. Second, the equilibrium strategies of firms are Pareto inferior for them when the condition relating to marginal effort costs and potential demands is satisfied. Thus, whether the coopetitive situation that firms exchange their accident information cooperatively and choose their quantity levels competitively is desirable for firms depends on the magnitude of the cost reduction and demand reduction effects.

THE ACTUAL ACCIDENTS[2]

In this section, we introduce two actual accidents that unveiled in 2006 in Japan. We review (a) a fatal instantaneous hot-water heater accident and (b) a shredder accident. Both are closely related to accident information sharing and have the following three common characteristics. (1) Similar (smaller) accidents had occurred before the serious accident. (2) There was no mechanism (laws and instituions) to share the accident information. (3) The mechanism of accident information sharing is examined after the accidents were announced. These accidents indicate that firms do not share the accident information voluntarily and so some systems such as laws and institutions are required to realize the coopetitive situation.

The fatal instantaneous hot-water heater accident[3]

This accident was announced by the Ministry of Economy, Trade and Industry (METI) in July of 2006. The METI is the responsible authority. This report stated that the instantaneous hot-water heaters made by Paloma-Consolidated, which has the second largest share of hot-water heaters in Japan, caused 28 carbon monoxide poisoning accidents, including 21 deaths from January of 1985 to November of 2005. This report also means that Paloma-Consolidated did not reveal its accident information before then.

The METI demanded the voluntary recall of the products to Paloma-Consolidated. According to a report from METI, 231 out of 18,221 instantaneous hot-water heaters

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[2] The descriptions are current as at 30 April 2008.
[3] See the Japan times (27, December 2006). Online available (URL: http://search.japantimes.co.jp/cgi-bin/nn20061227a6.html) (accessed 30 April, 2008).

were illegally remodeled. Furthermore, METI also revised the original bill of the Consumer Product Safety Law. This revised law was issued on December of 2006. It made the reporting of accident information to the manufacturer mandatory since May of 2007.[4] Furthermore, on September of 2006, the National Consumer Affairs Center of Japan (NCAC) announced that it would offer this accident information regarding death and serious injury to some ministries in order to promote information sharing among the manufacturers.[5]

The shredder accident[6]

This accident was announced by METI in August of 2006. METI is the responsible authority, as in the previous case. This report stated that office shredders made by Irisohyama and Carl Manufacturing, which design, produce and sell stationery including shredders, cut the fingers of infants aged two years. The accidents involving Irisohyama and Carl Manufacturing occurred in March and July of 2006, respectively. Both manufacturers apologized soon after this report and submitted a prevention plan to METI.

Irisohyama admitted that the same type of shredder continued to sell after the accident had occurred. The president of Irisohyama stated that this type of accident was a very rare case. However, after these accidents were revealed, many similar reports

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[4] Manufacturers must report accident information to METI within 10 days of the accident occurring.
[5] According to the homepage of NCAC (URL: http://www.kokusen.go.jp/ncac_index_e.html (accessed 30 April, 2008)), its mission is "to provide information and conduct surveys from a comprehensive perspective to contribute to the stability and improvement of people's lives." In order to realize this mission, it provides accident information to the public.
[6] See the Japan times (6, August 2006). Online available (URL: http://search.japantimes.co.jp/mail/nn20060824a3.html) (accessed 30 April, 2008).

were received. For example, the shredders made by Ricoh Company, which produces and sells digital copy machines and so forth, caused seven similar accidents from 1985 to 1997.[7]

Because METI is also the responsible authority, the revised Consumer Product Safety Law and the activities of the NCAC mentioned above may improve the safety of shredders.

METHODOLOGY[8]

This article analyzes the coopetitive situation using the game theory. Game theory can shed light on situations where firms and other organizations are faced with strategic interactions in which individual action directly affects the payoffs of others (Shy 1995: 11). Coopetitive situation contains several strategic interactions in terms of both private and common goals.

To analyze the coopetitive situation, we consider not only cooperative and competitive phases individually but also whole phases collectively. Game theory permits us to analyze a complex situation by distinguishing in an analytical fashion the cooperative and competitive issues. In the terminology of game theory, coopetition can be depicted as an extensive-form game containing both cooperative and competitive phases. An extensive-form game can be solved phase by phase. Generally, the optimal strategies in the competitive phase can be derived given all strategies that firms choose

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[7] See the Japan times (25, August 2006). Online available (URL: http://search.japantimes.co.jp/cgi-bin/nn20060825a6.html) (accessed 30 April, 2008).
[8] This section is strongly based on Okura (2007). See also Lado et al. (1997) and Okura (2008).

in the cooperative situation and the optimal strategies in the cooperative phase can be derived by using the computation results in the competitive phase. There are literatures that explain the use of such framework to analyze coopetitive situation, for example, Ngo (2006) and Ngo and Okura (2008).

For that view, game theory is a powerful tool for analyzing coopetitive situations, including cooperative accident information sharing and competitive effort and quantity setting. In brief, game theory can explain complicated situations where firms act strategically in multiple decision stages in a formal manner.

THE MODEL

There are two firms: A and B. We set out the following three-stage game. In the first stage, both firms choose whether to disclose previous accident information to their competitor. Firm i can reduce the effort cost to improve the safety level of its products if the competitor discloses its accident information ($i, \in \{A, B\}$). In this case, firm i's effort cost function can be written as:

$$c^D(e_i) = \frac{1}{2} a^D e_i^{\,2}.$$

(1)

On the other hand, if the competitor does not disclose its accident information, firm i's effort cost function can be written as:

$$c^N(e_i) = \frac{1}{2} a^N e_i^{\,2},$$

(2)

where $0 < a^D < a^N < \infty$. This means the firm can lower marginal effort cost by using the competitor's accident information.

However, spreading the accident information may build a bad reputation and reduce demand. Thus, the demand function is given by:

$$p = \alpha^{jk} - q_A - q_B, \tag{3}$$

where p denotes the market price, and q_i represents the quantity supplied by firm i. α^{jk} for $j,k \in \{D,N\}$ is potential demand and we assume that $0 < \alpha^{DD} \leq \alpha^{ND} = \alpha^{DN} \leq \alpha^{NN} < \infty$. This assumption indicates that the more the accident information spreads to the public, the more potential demand falls.[9]

In the second stage, after observing both decisions, the firms choose their effort levels for safety management simultaneously. The higher the safety levels, the lower the expected costs such as maintenance and lawsuit costs that the firms may have to pay after the sale of the product.[10] In the model, these expected costs can be expressed as:

$$d = x - e_i, \tag{4}$$

where x denotes the maximum level of these expected costs, and we assume that $x < \alpha^{DD}$.

In the third stage, after observing both effort levels, the firms choose their product sales levels simultaneously. Each firm is assumed to be risk neutral and each profit function, which is denoted by π_i^{jk}, takes the form:

$$\pi_A^{jk} = \left(p - C^k(e_A)\right)q_A, \tag{5}$$

$$\pi_B^{jk} = \left(p - C^j(e_B)\right)q_B, \tag{6}$$

where $C^k(e_A) \equiv c^k(e_A) + (x - e_A)$ and $C^j(e_B) \equiv c^j(e_B) + (x - e_B)$.

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[9] If the accident information can spread completely secretly, potential demand is not lowered; that is, $\alpha^{DD} = \alpha^{ND} = \alpha^{DN} = \alpha^{NN}$.
[10] In general, Japanese manufacturers guarantee to repair or replace their products free of charge for a year.

There are two justifications for this three-stage setup from literatures in coopetition studies. First, Walley (2007: 17) said, "firms in a coopetitive relationship frequently cooperate in the upstream activities and compete in the downstream activities." In this case, decision about information sharing is upstream activity, while decisions about effort and product sales levels are downstream activities. Second, according to Bengtsson and Kock (2000: 418), firms cooperate in input activities before competing in output activities. In this case, decision about information sharing is an input activity, while decisions about effort and product sales levels are output activities.

We can derive a subgame perfect equilibrium by backward induction. First, we analyze the second and third stages, given the decision taken in the first stage. Next, we check all four strategy sets, {disclose, disclose}, {disclose, not disclose}, {not disclose, disclose}, and {not disclose, not disclose}, in the subsequent section.

The case of {disclose, disclose}

Assume that both firms disclose their accident information in the first stage. The first-order optimality conditions in the third stage are:

$$\frac{\partial \pi_A^{DD}}{\partial q_A} = \alpha^{DD} - 2q_A - q_B - C^D(e_A) = 0, \tag{7}$$

$$\frac{\partial \pi_B^{DD}}{\partial q_B} = \alpha^{DD} - q_A - 2q_B - C^D(e_B) = 0. \tag{8}$$

By combining equations (7) and (8), we obtain:

$$q_A^{DD} = \frac{\alpha^{DD} - 2C^D(e_A) + C^D(e_B)}{3}, \tag{9}$$

$$q_B^{DD} = \frac{\alpha^{DD} - 2C^D(e_B) + C^D(e_A)}{3}. \tag{10}$$

Substituting equations (9) and (10) into each profit function, it can be seen that:

$$\pi_A^{DD} = \left(\frac{\alpha^{DD} - 2C^D(e_A) + C^D(e_B)}{3} \right)^2 , \tag{11}$$

$$\pi_B^{DD} = \left(\frac{\alpha^{DD} - 2C^D(e_B) + C^D(e_A)}{3} \right)^2 . \tag{12}$$

The first-order optimality conditions in the second stage are:

$$\frac{\partial \pi_A^{DD}}{\partial e_A} = 2\left(-a^D e_A + 1\right)\left(\frac{\alpha^{DD} - 2C^D(e_A) + C^D(e_B)}{3} \right) = 0 , \tag{13}$$

$$\frac{\partial \pi_B^{DD}}{\partial e_B} = 2\left(-a^D e_B + 1\right)\left(\frac{\alpha - 2C^D(e_B) + C^D(e_A)}{3} \right) = 0 . \tag{14}$$

Then, we have:

$$e_A^{DD} = e_B^{DD} = \frac{1}{a^D} . \tag{15}$$

Substituting equation (15) into equations (11) and (12), the equilibrium profits for each firm become:

$$\pi_A^{DD} = \pi_B^{DD} = \frac{1}{9}\left(\alpha^{DD} - x + \frac{1}{2a^D} \right)^2 . \tag{16}$$

The case of {not disclose, not disclose}

In this case, the equilibrium profits can be obtained by replacing the superscripts as follows.

$$\pi_A^{NN} = \pi_B^{NN} = \frac{1}{9}\left(\alpha^{NN} - x + \frac{1}{2a^N} \right)^2 . \tag{17}$$

The case of {disclose, not disclose}

This is an asymmetric case where firm A discloses its accident information but firm B does not disclose. In this case, we can derive the first-optimality conditions in the third stage as follows.

$$\frac{\partial \pi_A^{DN}}{\partial q_A} = \alpha^{DN} - 2q_A - q_B - C^N(e_A) = 0, \tag{18}$$

$$\frac{\partial \pi_B^{DN}}{\partial q_B} = \alpha^{DN} - q_A - 2q_B - C^D(e_B) = 0. \tag{19}$$

By combining equations (18) and (19), we obtain:

$$q_A^{DN} = \frac{\alpha^{DN} - 2C^N(e_A) + C^D(e_B)}{3}, \tag{20}$$

$$q_B^{DN} = \frac{\alpha^{DN} - 2C^D(e_B) + C^N(e_A)}{3}. \tag{21}$$

Substituting equations (20) and (21) into each profit function, it can be seen that:

$$\pi_A^{DN} = \left(\frac{\alpha^{DN} - 2C^N(e_A) + C^D(e_B)}{3}\right)^2, \tag{22}$$

$$\pi_B^{DN} = \left(\frac{\alpha^{DN} - 2C^D(e_B) + C^N(e_A)}{3}\right)^2. \tag{23}$$

The first-order optimality conditions in the second stage are:

$$\frac{\partial \pi_A^{DN}}{\partial e_A} = 2(-a^N e_A + 1)\left(\frac{\alpha^{DN} - 2C^N(e_A) + C^D(e_B)}{3}\right) = 0, \tag{24}$$

$$\frac{\partial \pi_B^{DN}}{\partial e_B} = 2(-a^D e_B + 1)\left(\frac{\alpha^{DN} - 2C^D(e_B) + C^N(e_A)}{3}\right) = 0. \tag{25}$$

Then, we have:

$$e_A^{DN} = \frac{1}{a^N}, \tag{26}$$

$$e_B^{DN} = \frac{1}{a^D}. \tag{27}$$

Substituting equations (26) and (27) into equations (22) and (23), the equilibrium profits for each firm become:

$$\pi_A^{DN} = \frac{1}{9}\left(\alpha^{DN} - x + \frac{1}{a^N} - \frac{1}{2a^D}\right)^2, \tag{28}$$

$$\pi_B^{DN} = \frac{1}{9}\left(\alpha^{DN} - x + \frac{1}{a^D} - \frac{1}{2a^N}\right)^2. \tag{29}$$

The case of {not disclose, disclose}

This is the opposite case. Firm A does not disclose its accident information, but firm B does disclose. Thus, the equilibrium profits can be obtained by replacing the superscripts as follows.

$$\pi_A^{ND} = \frac{1}{9}\left(\alpha^{ND} - x + \frac{1}{a^D} - \frac{1}{2a^N}\right)^2, \tag{30}$$

$$\pi_B^{ND} = \frac{1}{9}\left(\alpha^{ND} - x + \frac{1}{a^N} - \frac{1}{2a^D}\right)^2. \tag{31}$$

DERIVING THE EQUILIBRIUM

Next consider the first stage. In Table 1, firm A's decisions are identified in the rows and firm B's are identified in the columns. The left-hand value in each box is firm A's profit, and the right-hand value is firm B's profit.

Insert Table 1 about here

From Table 1, we can derive the following proposition.

Proposition 1: In the three-stage game, {not disclose, not disclose} is a unique subgame perfect equilibrium.

Proof:

Because $\alpha^{DN} = \alpha^{ND} \geq \alpha^{DD}$ and $\dfrac{1}{a^D} - \dfrac{1}{2a^N} > \dfrac{1}{2a^D}$, then $\pi_A^{ND} > \pi_A^{DD}$ and

$\pi_B^{DN} > \pi_B^{DD}$. Thus, either firm changes to the "not disclose" strategy when both firms

initially choose the "disclose" strategy. Furthermore, because $\alpha^{NN} \geq \alpha^{DN} = \alpha^{ND}$ and

$\dfrac{1}{2a^N} > \dfrac{1}{a^N} - \dfrac{1}{2a^D}$, then $\pi_A^{NN} > \pi_A^{DN}$ and $\pi_B^{NN} > \pi_B^{ND}$. Thus, the firm that chooses the

"disclose" strategy changes to the "not disclose" strategy when its competitor initially

chooses the "not disclose" strategy.

Q. E. D.

Proposition 1 indicates that both firms do not disclose their accident information

voluntarily because they can get more profits in the case of "not disclose" than

"disclose" whichever the competitor chooses. Furthermore, the outcome in the subgame

perfect equilibrium has a meaningful characteristic in the following proposition.

Proposition 2: The outcome in the subgame perfect equilibrium becomes Pareto inferior to the outcome where both firms choose the "disclose" strategy when the following condition is met.

$$a^N - a^D > 2a^D a^N \left(\alpha^{NN} - \alpha^{DD}\right). \tag{32}$$

Proof:

It is easy to calculate the following equation.

$$\pi_i^{DD} - \pi_i^{NN} = \frac{\left[a^N - a^D \left\{1 + 2a^N\left(\alpha^{NN} - \alpha^{DD}\right)\right\}\right]\left[a^N + a^D\left\{1 + 2a^N\left(\alpha^{NN} + \alpha^{DD} - 2x\right)\right\}\right]}{\left(6a^D a^N\right)^2}. \tag{33}$$

Thus, we can obtain the following condition because $\alpha^{NN} + \alpha^{DD} - 2x > 0$.

$$\pi_i^{DD} - \pi_i^{NN} > 0 \Rightarrow a^N - a^D \left\{1 + 2a^N\left(\alpha^{NN} - \alpha^{DD}\right)\right\} > 0. \tag{34}$$

From equation (34), we can derive equation (32).

Q. E. D.

Proposition 2 means that the equilibrium strategies of both firms are inferior for them only if the equation (32) relating to marginal effort costs and potential demand is satisfied. The reason why the result is ambiguous, when both firms choose "disclose", there are two opposing effects. First, disclosing accident information increases firm profits through cost reduction (cost reduction effect). Second, it lowers potential demand from α^{NN} to α^{DD} (demand reduction effect). Thus, there is no unique result

because we cannot compare the magnitudes of these effects. From proposition 2, it is easy to obtain the following lemma.

Lemma: If there is no demand reduction effect, that is, $\alpha^{DD} = \alpha^{ND} = \alpha^{DN} = \alpha^{NN}$, the outcome in the subgame perfect equilibrium is always Pareto inferior to the outcome when both firms choose the "disclose" strategy.

This lemma indicates the special case where the demand does not change in accordance with the degree of information sharing. In this case, the equilibrium strategies of both firms are always inferior for them. In this regard, we find that, if the demand reduction effect is small, it is desirable for firms to disclose accident information through some mechanism because the cost reduction effect is constant. On the other hand, if the demand reduction effect is so large that equation (33) is not satisfied, the remaining the subgame perfect equilibrium is desirable for firms.[11]

In summary, whether the coopetitive situation where firms exchange their accident information cooperatively and choose their effort and quantity levels competitively is desirable for firms depends on the magnitude of the cost reduction and demand reduction effects.

CONCLUDING REMARKS

This article derives two propositions. In Proposition 1, in the three-stage game that

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[11] Furthermore, if there are costs in coordinating cooperative information usage, the desirability to realize the coopetitive situation is lowered. These costs include costs for legal procedures and costs for information processing.

includes decisions on accident information disclosure, effort for safety management, and sales quantities, there is a unique subgame perfect equilibrium where both firms choose to not disclose their accident information. Proposition 2 shows that the outcome in a subgame perfect equilibrium becomes Pareto inferior to the outcome where both firms choose the "disclose" strategy when the condition relating to marginal effort costs (a^D and a^N) and potential demands (α^{DD} and α^{NN}) is met. This proposition also demonstrates that whether the coopetitive situation where firms exchange their accident information cooperatively and choose their quantity levels competitively is desirable for firms depends on the magnitude of cost reduction and demand reduction effects. In this article, unlike Okura (2007, 2008), coordinating some activities and realizing coopetitive situations may not be desirable for firms.

Eventually, we conclude that coopetitive situation cannot arise voluntarily because firms can get more profits in the case of "not disclose" than "disclose" whichever the competitor chooses. This conclusion can explain why the revised Consumer Product Safety Law that made the reporting of accident information by the manufacturer mandatory exists. Furthermore, we cannot judge whether it is desirable for firms to realize the coopetitive situation because there are two opposing effects (cost reduction effect and demand reduction effect). Thus, there may be no incentives to provide METI the accident information if the outcome when the firms choose the "disclose" strategy is not Pareto inferior to the outcome when the firms choose the "not disclose" strategy even if firms can negotiate after the outcome is realized. From that view, offering the accident information regarding death and serious injury by NCAC can serve as a very useful way to promote information sharing among the firms.

There are some possible extensions for the future research. For example, we did not

consider the demand side except for the demand functions. Thus, one possible future research is to consider whether making accident information sharing to firms mandatory is desirable in terms of social welfare. In another example, we implicitly assumed that a firm always obtains the advantage if it obtains accident information from its competitor. However, if a firm has already obtained exactly the same information before the first stage begins, it cannot obtain any advantage. In this regard, we can extend the model including the information quality factor.

Our contributions to coopetition research have both methodological and explanatory aspects. In terms of methodology, we confirmed that game theory is a powerful tool with which to analyze complicated coopetitive situations that described in Brandenburger and Nalebuff (1996). Coopetition studies tend to be complicated because coopetition involves at least two types of activities (cooperative and competitive) by definition. In terms of explanation, we concluded that realizing the coopetitive situation might not be desirable for firms. Thus, like as Luo (2005), it is important to consider "why coopetition occurs" and "what are the critical determinants of coopetition".

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TABLE 1

Profit matrix in the first stage

	Disclose	Not Disclose
Disclose	$\frac{1}{9}\left(\alpha^{DD} - x + \frac{1}{2a^D}\right)^2, \frac{1}{9}\left(\alpha^{DD} - x + \frac{1}{2a^D}\right)^2$	$\frac{1}{9}\left(\alpha^{DN} - x + \frac{1}{a^N} - \frac{1}{2a^D}\right)^2, \frac{1}{9}\left(\alpha^{DN} - x + \frac{1}{a^D} - \frac{1}{2a^N}\right)^2$
Not Disclose	$\frac{1}{9}\left(\alpha^{ND} - x + \frac{1}{a^D} - \frac{1}{2a^N}\right)^2, \frac{1}{9}\left(\alpha^{ND} - x + \frac{1}{a^N} - \frac{1}{2a^D}\right)^2$	$\frac{1}{9}\left(\alpha^{NN} - x + \frac{1}{2a^N}\right)^2, \frac{1}{9}\left(\alpha^{NN} - x + \frac{1}{2a^N}\right)^2$