Decisions of Duopoly Firms on Sharing Information on Their Delegation Contracts

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Abstract

We study duopolies in which firms – each of which consists of an owner and a manager – have the option of releasing or not to the public their contract information between the owner and the manager. The owner of each firm seeks to maximize her firm's profits, and designs a compensation scheme for her manager in which the manager's compensation depends on his performance: a linear combination of the firm's profits and sales. After accepting contracts, the managers compete in quantities or in prices. As a main result, we show in both quantity-setting and price-setting models that the firms both release their contract information. Then, we compare the outcomes of the observable-contracts case with those of the unobservable-contracts case.

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1. Introduction

In some countries, firms are obliged to disclose information about their CEO compensation contracts, while in others there are no disclosure requirements on it.[1] Even under mandatory disclosure rules, firms still have substantial discretion as to whether to disclose their true contract information.

A natural and interesting question is, then, whether firms have incentives to disclose – and whether they actually disclose – true information about their CEO compensation contracts. Another interesting question is whether such mandatory disclosure regulations benefit either consumers or firms, or both. Yet another interesting question is whether such mandatory disclosure regulations increase social welfare. To the best of our knowledge, however, these questions have not been addressed previously.

Accordingly, we consider situations in which firms – each of which consists of an owner and a manager – have the option of releasing or not their contract information between the owner and the manager. The purpose of this paper is to address those questions, focusing on whether the firms release their contract information.[2] We do this in two separate cases. One is the case of strategic substitutes in which the firms compete in quantities.[3] The other is the case of strategic complements in which the firms compete in prices.

Formally, we study duopolies in which each firm has an owner and a manager. In the duopolies, each firm first announces whether it will release to the public its contract information between the owner and the manager. Next, the owner of each firm writes – and releases if her

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[1]In the United States, publicly traded firms must disclose information about their CEO compensation contracts. In the United Kingdom, large and medium-sized public companies are required to disclose comparative information about the pay of chief executives and employees. In Germany, stock corporations are required to disclose the remuneration packages individually in the companies' annual reports. In Canada, firms should disclose the amount and composition of individual compensation of the five highest-paid executives.

[2]By stating that the firms *release* their contract information, we mean that the firms disclose their *true* contract information.

[3]Bulow et al. (1985) define two terms: strategic substitutes and strategic complements. In the literature on oligopoly, outputs are usually regarded as strategic substitutes, while prices are usually regarded as strategic complements.

firm announced to do so – a contract with her manager in which the manager's compensation depends on his performance, which is measured by a linear combination of the firm's profits and sales. Finally, the managers in both firms compete in quantities or in prices.

What is a main motive of such delegation? It is that the owner of each firm wants to benefit by achieving strategic commitments through delegation.[4] Indeed, she can change the rival firm's behavior in her favor, by using her manager whose objective function differs from hers.

We develop two (main) models: a model with quantity-setting firms and one with price-setting firms. These models differ only in that the first model assumes a quantity-setting duopoly with homogeneous products, while the second model assumes a price-setting duopoly with differentiated products. By considering the models, we can further our understanding of firms' behavior with regard to contract information disclosure and its effects on contracts, managerial decisions, profits, etc. Also, we can distinguish the benefits and costs – in terms of consumer surplus, profits, and welfare – of regulations that require firms to disclose their contract information. Furthermore, with this knowledge, we may be able to argue for or against such mandatory disclosure regulations.

As a main result of this paper, we show in both quantity-setting and price-setting models that both firms announce that they will release their contract information, and they actually do release it.[5] Then, we compare the outcomes – consumer surplus, profits, welfare, etc. – of the observable-contracts case with those of the unobservable-contracts case.[6] We show that the welfare that results from the observable-contracts case is greater than that resulting from the unobservable-contracts case – in both quantity-setting and price-setting markets.

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[4]There is a vast literature on strategic delegation. Examples include Schelling (1960), Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987).

[5]Note that, unlike many results in the literature on oligopoly, this main result does not depend on whether the strategic variables are strategic substitutes or strategic complements.

[6]By the observable-contracts (unobservable-contracts) case, we mean the one where each firm's contract is *exogenously* assumed to be observable (unobservable) to the rival firm. This comparison is interesting because the two cases are commonly observed in the real world.

1.1. Related literature

This paper is closely related to Fershtman and Judd (1987), Sklivas (1987), and Theilen (2007). They study duopolies with strategic managerial delegation; they assume *exogenously* that each manager *knows* the rival firm's contract information when choosing his firm's output level or price. The current paper can be viewed as extending Fershtman and Judd (1987) and Sklivas (1987) by incorporating firms' decisions on releasing their contract information.

This paper is also related to Fershtman and Kalai (1997), Koçkesen and Ok (2004), and Koçkesen (2007). They study delegation with unobservable contracts, and show that such delegation may yield strategic advantage to the delegating player or players. Specifically, Fershtman and Kalai (1997) consider incentive-delegation with unobservable contracts and instructive-delegation with unobservable instructions, and demonstrate when commitment via delegation is beneficial. Koçkesen and Ok (2004) consider a one-sided delegation game in which only one of the two principals has the option of hiring a delegate and the delegation contract, if any, is unobservable to the opponent. They show that – if the cost of hiring a delegate is relatively low – then strategic delegation may arise in equilibrium.

This paper is broadly related to the literature on information sharing: See, for example, Vives (1984), Gal-Or (1985), Raith (1996), Gill (2008), Jansen (2010), Baik and Lee (2012), Cho and Jun (2013), and Kovenock et al. (2015). These papers examine, in different contexts, whether firms or, in general, players have incentives to share their private information with their rivals. For example, Vives (1984) considers a duopoly model in which each firm has private information about an uncertain linear demand, and shows that if the goods are substitutes, then not sharing information (sharing information) is a dominant strategy for each firm in Cournot (Bertrand) competition; if the goods are complements, then the result is reversed.

2. The model with quantity-setting firms

Consider a quantity-setting duopoly in which two firms – 1 and 2 – produce and sell homogeneous products. Each firm has an owner and a manager. Each firm first announces

whether or not to release to the public the information about its contract between the owner and the manager. Then, the owner of each firm writes – and releases if her firm announced to do so – a contract with her manager that specifies how the manager will be rewarded. Finally, each manager chooses his firm's output level.

Let x_i, for $i = 1, 2$, represent firm i's output level, where $x_i \in R_+$. Firm i's cost function is given by $c(x_i) = cx_i$ for all $x_i \in R_+$, where $c(x_i)$ represents firm i's cost of producing x_i units of its product, and c represents a constant marginal cost to firm i.

Both firms' products are sold at a single price, which is determined by the inverse market demand function together with the firms' output levels:

$$\begin{aligned} P = \quad & a - bX \qquad && \text{for } 0 \leq X \leq a/b \\ & 0 \qquad && \text{for } X > a/b, \end{aligned}$$

where P represents the market price, a and b are positive constants, and $X = x_1 + x_2$. We assume that $0 < c < a$.

Let π_i represent firm i's profits (without subtracting its manager's compensation), and let S_i represent firm i's sales, for $i = 1, 2$. Each owner uses a compensation scheme for her manager in which the manager's compensation depends on his performance, which is measured by a linear combination of the firm's profits and sales. Manager i is given an incentive to maximize

$$O_i = \alpha_i \pi_i + (1 - \alpha_i) S_i,$$

where a value of α_i is chosen when owner i writes a contract with her manager. We put no restrictions on α_i. A larger value of α_i implies that more emphasis is placed on profits.

More specifically, we assume that owner i uses a compensation scheme in which manager i is paid $A_i + B_i O_i$, where A_i and B_i are constants with $A_i \geq 0$ and $B_i > 0$ (see Fershtman and Judd 1987). Under this compensation scheme, once values of A_i and B_i (as well as a value of α_i) are chosen, manager i's compensation is determined by O_i.

Manager i has a reservation wage of R_i, where R_i is positive. This implies that – if his equilibrium compensation will fall short of R_i – then manager i prefers not to work for owner i (or firm i), and will accept alternative employment instead. On the other hand, it never happens that the contract that is designed by owner i will provide manager i with equilibrium compensation greater than R_i. With the compensation scheme, for any O_i, owner i can pay manager i exactly his reservation wage R_i by choosing appropriate values of A_i and B_i.

Given an incentive structure that is a linear combination of profits and sales, manager i, for $i = 1, 2$, seeks to maximize

$$\begin{aligned} O_i &= \alpha_i \{(a - bX)x_i - cx_i\} + (1 - \alpha_i) \{(a - bX)x_i\} \\ &= (a - bX)x_i - \alpha_i c x_i. \end{aligned} \tag{1}$$

On the other hand, we assume that each owner's objective is to maximize her firm's profits net of her manager's compensation. Mathematically, this amounts to assuming that owner i seeks to maximize her firm's profits

$$\pi_i = (a - bX)x_i - cx_i, \tag{2}$$

because any contract that is designed by owner i provides manager i with equilibrium compensation that is exactly equal to his reservation wage R_i.

Each firm has the option of releasing or not its contract information to the public. We assume that each firm announces – before choosing its contract – whether it will release its contract information. We assume also that each firm decides to release its contract information only if both the owner and the manager of the firm agree to do so. Note that this amounts to assuming that each firm's decision on releasing its contract information is made only by its owner, because its manager – who will be paid his reservation wage regardless of the decision outcome – is indifferent between releasing and not releasing the contract information.

We formally consider the following game: First, each firm decides independently whether it will release its contract information to the public. The firms simultaneously announce

and commit to their decisions before writing their contracts. Next, the owner of each firm writes – and releases if her firm announced to do so – a contract with her manager. That is, owner i, for $i = 1, 2$, chooses values of α_i, A_i, and B_i.[7] (We will be more specific about this stage – in particular, about the timing of the firms' contract decisions – in Section 3.) Finally, the managers of both firms choose their firms' output levels simultaneously and independently.

We assume that all of the above is common knowledge among the owners and managers.

3. The firms both release their contract information

To solve the game, we work backward: We first analyze the subgames that start after the firms announce whether they will release their contract information, and then consider the firms' decisions on releasing their contract information.

There are four subgames that start after the firms announce whether they will release their contract information: the (*R*, *R*) subgame; the (*R*, *NR*) subgame; the (*NR*, *R*) subgame; and the (*NR*, *NR*) subgame, where *R* denotes the action of announcing that the firm will release its contract information, and *NR* denotes the action of announcing that it will not release its contract information.

3.1. The (*R*, *R*) *subgame*

This subgame has two stages: In the first stage, each firm chooses its contract independently, and then the firms release their contract information simultaneously. In the second stage, after observing the values of α_1 and α_2, the managers in both firms choose their firms' output levels simultaneously and independently.

[7]Once values of α_i, A_i, and B_i are chosen, manager i's compensation is determined by O_i. Thus, for concise exposition, we will restrict attention only to the value of α_i.

To solve for a subgame-perfect equilibrium of the (R, R) subgame, we work backward.[8] Lemma 1 summarizes the outcomes of the (R, R) subgame:

Lemma 1. (a) *In the equilibrium of the* (R, R) *subgame*, *owner* i, *for* $i = 1, 2$, *chooses* $\alpha_i^R = (6c - a)/5c$, *and manager* i *chooses* $x_i^R = 2(a - c)/5b$. (b) *The firms' equilibrium profits are* $\pi_1^R = \pi_2^R = 2(a - c)^2/25b$.

3.2. The (R, NR) *subgame and the* (NR, R) *subgame*

Consider a subgame in which firm i releases its contract information, but firm j does not, for $i, j = 1, 2$ with $i \neq j$. Note that we are considering the (R, NR) subgame if $i = 1$, and the (NR, R) subgame if $i = 2$.

We assume that firm j chooses its contract after observing firm i's contract.[9] This subgame is then described as follows: First, owner i chooses and releases a value of α_i, and then, after observing the value of α_i, owner j chooses a value of α_j. Next, manager i observes only the value of α_i, but manager j observes the values of α_1 and α_2. Finally, managers 1 and 2 simultaneously choose their firms' output levels. Note that owner i is the strategical leader in this subgame.

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[8]For concise exposition, we omit the detailed analysis of this standard two-stage game. It is available from the authors upon request. See also Fershtman and Judd (1987) and Sklivas (1987).

[9]Alternatively, we may assume that firm j chooses its contract without or before observing firm i's contract. Given this assumption, we use the solution technique introduced in Baik and Lee (2018) to solve the subgame. With the alternative assumption, however, we obtain the same main results as those with the current assumption, both in the quantity-setting model and in the price-setting model.

We solve the subgame by viewing it as the following two-stage game.[10] In the first stage, owner i chooses and releases a value of α_i. In the second stage, after observing the value of α_i, manager i and firm j play a simultaneous-move game. Specifically, manager i chooses his firm's output level, without observing the value of α_j or firm j's output level; owner j chooses a value of α_j, and manager j (after observing the value of α_j) chooses his firm's output level; both actions occur without either j entity's observing firm i's output level.

To solve this two-stage game, we work backward. In the second stage, manager i and firm j know the value of α_i. We begin by deriving the reaction function for manager i. After observing α_i, manager i seeks to maximize O_i in (1) over his firm's output level x_i, taking firm j's output level x_j as given. From the first-order condition for maximizing O_i, we obtain manager i's reaction function:[11]

$$x_i(x_j; \alpha_i) = (a - \alpha_i c)/2b - x_j/2. \tag{3}$$

It is straightforward to check that the second-order condition for maximizing O_i is satisfied.[12]

Next, consider firm j. Owner j chooses a value of α_j, and then manager j chooses his firm's output level; both actions occur without either j entity's observing firm i's output level. Working backward, we first consider manager j's decision on his firm's output level. After

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[10]Baik and Lee (2012) develop a solution technique for games between two parties in which each party has two sequential moves; the first action that is chosen by one party is observed by the rival party before the rival party chooses its first action, but the first action that is chosen by the other party is not observed by the rival party; and the parties choose their second actions simultaneously. We use their solution technique to solve the subgames in Sections 3.2 and 5.2.

Note that the equilibrium actions that are obtained by using their solution technique are a sequential equilibrium outcome – the actions that are specified in a sequential equilibrium – and also a perfect Bayesian equilibrium outcome (see, for example, Gibbons 1992; Osborne and Rubinstein 1994). Koçkesen and Ok (2004) characterize the set of sequential equilibrium outcomes of a one-sided delegation game. Koçkesen (2007) characterizes the set of sequential equilibrium outcomes of a two-sided delegation game.

[11]Because we focus on interior solutions or because symmetric equilibria occur, we omit, for concise exposition, complete and precise descriptions of reaction functions throughout the paper.

[12]The second-order condition is satisfied for every maximization problem in the paper. For concise exposition, we do not state it explicitly in each case.

observing the values of α_1 and α_2, manager j seeks to maximize O_j in (1) over his firm's output level x_j, taking firm i's output level x_i as given. From the first-order condition for maximizing O_j, we obtain manager j's reaction function:

$$x_j(x_i;\, \alpha_1, \alpha_2) \;=\; (a - \alpha_j c)/2b \;-\; x_i/2. \tag{4}$$

Then, we consider owner j's decision on the value of α_j. Owner j seeks to maximize

$$\begin{aligned} \pi_j(x_i, \alpha_j;\, \alpha_i) \;&=\; \{a - bx_i - bx_j(x_i;\, \alpha_1, \alpha_2)\}\, x_j(x_i;\, \alpha_1, \alpha_2) \;-\; cx_j(x_i;\, \alpha_1, \alpha_2) \\ &=\; (a - 2c + \alpha_j c - bx_i)\,(a - \alpha_j c - bx_i)/4b \end{aligned} \tag{5}$$

with respect to α_j, taking firm i's output level x_i as given. Note that we obtain (5) by substituting (4) into (2). From the first-order condition for maximizing (5), we obtain another reaction function of firm j, or owner j's reaction function:

$$\alpha_j(x_i;\, \alpha_i) \;=\; 1. \tag{6}$$

By solving the system of three simultaneous equations, (3), (4), and (6), we obtain

$$\begin{aligned} x_i(\alpha_i) \;&=\; (a - 2\alpha_i c + c)/3b; \\ x_j(\alpha_i) \;&=\; (a + \alpha_i c - 2c)/3b; \\ \text{and} \qquad \alpha_j(\alpha_i) \;&=\; 1. \end{aligned} \tag{7}$$

These are the equilibrium output level of firm i, that of firm j, and the equilibrium value of α_j, respectively, in the second stage.

Next, consider the first stage in which owner i chooses a value of α_i. Having perfect foresight about $\pi_i(\alpha_i)$ for any values of α_i, owner i chooses a value of α_i that maximizes

$$\pi_i(\alpha_i) \;=\; (a + \alpha_i c - 2c)\,(a - 2\alpha_i c + c)/9b. \tag{8}$$

Note that we obtain (8) by substituting $x_i(\alpha_i)$ and $x_j(\alpha_i)$ in (7) into (2). From the first-order condition for maximizing (8) with respect to α_i, we obtain the equilibrium value of α_i in the subgame:

$$\alpha_i^{iR} = (5c - a)/4c.$$

Note that, henceforth, the superscript *iR* indicates the outcomes of the subgame in which firm *i* releases its contract information, but firm *j* does not, for $i, j = 1, 2$ with $i \neq j$.

Now, substituting α_i^{iR} into $x_i(\alpha_i)$, $x_j(\alpha_i)$, and $\alpha_j(\alpha_i)$ in (7), we obtain the firms' equilibrium output levels, x_i^{iR} and x_j^{iR}, and the equilibrium value of α_j, denoted by α_j^{iR}, in the subgame. Next, using these equilibrium actions, we obtain the firms' equilibrium profits, π_1^{iR} and π_2^{iR}, in the subgame.

Lemma 2 summarizes the outcomes of the (*R*, *NR*) subgame if $i = 1$, and those of the (*NR*, *R*) subgame if $i = 2$:

Lemma 2. (*a*) *In the equilibrium of a subgame in which firm i releases its contract information, but firm j does not, for* $i, j = 1, 2$ *with* $i \neq j$, *owner i chooses* $\alpha_i^{iR} = (5c - a)/4c$, *and manager i chooses* $x_i^{iR} = (a - c)/2b$. *Owner j chooses* $\alpha_j^{iR} = 1$, *and manager j chooses* $x_j^{iR} = (a - c)/4b$. (*b*) *The equilibrium profits of firm i and those of firm j are* $\pi_i^{iR} = (a - c)^2/8b$ *and* $\pi_j^{iR} = (a - c)^2/16b$, *respectively*.

3.3. The (*NR*, *NR*) *subgame*

In this subgame, each firm chooses two *sequential* actions – specifically, its contract and then its output level – without observing those chosen by the other firm. That is, the two firms play a simultaneous-move game.[13]

[13]Baik and Lee (2007) come up with a solution technique for games between two parties in which each party has two sequential moves; the first action chosen by each party is not observed by the rival party; and the parties choose their second actions simultaneously. We use their

The equilibrium values of α_1 and α_2 and the equilibrium output levels of the firms in the subgame satisfy the following two requirements. First, firm *i*'s output level is optimal given the value of α_i and given firm *j*'s output level, for $i, j = 1, 2$ with $i \neq j$. In other words, firm *i*'s output level is a best response both to the value of α_i and to firm *j*'s output level. Second, the value of α_i is optimal given firm *j*'s output level and given firm *i*'s own subsequent optimal behavior, or rather its optimal output level.

To obtain the equilibrium values of α_1 and α_2 and the equilibrium output levels of the firms, we begin by deriving the reaction functions for firm *i*. Working backward, we first consider manager *i*'s decision on his firm's output level. After observing the value of α_i, manager *i* seeks to maximize O_i in (1) over his firm's output level x_i, taking firm *j*'s output level x_j as given. From the first-order condition for maximizing O_i, we obtain manager *i*'s reaction function:

$$x_i(x_j; \alpha_i) = (a - \alpha_i c)/2b - x_j/2. \tag{9}$$

Then, we consider owner *i*'s decision on the value of α_i. Owner *i* seeks to maximize

$$\pi_i(x_j, \alpha_i) = (a - 2c + \alpha_i c - bx_j)(a - \alpha_i c - bx_j)/4b \tag{10}$$

with respect to α_i, taking firm *j*'s output level x_j as given. Note that we obtain (10) by substituting (9) into (2). From the first-order condition for maximizing (10), we obtain another reaction function of firm *i*, or owner *i*'s reaction function:

$$\alpha_i(x_j) = 1. \tag{11}$$

Now, we denote the firms' equilibrium actions by $(\alpha_1^{NR}, x_1^{NR}, \alpha_2^{NR}, x_2^{NR})$. We obtain them by solving the system of four simultaneous equations, which comes from (9) and (11). Substituting (11) into (9), we have

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solution technique to solve the subgames in Sections 3.3 and 5.3. Note that their solution technique is also used in Baik and Lee (2012), Baik and Kim (2014), and Baik (2016).

$$x_1(x_2) = (a-c)/2b - x_2/2;$$

and

$$x_2(x_1) = (a-c)/2b - x_1/2.$$

By solving this pair of simultaneous equations, we obtain the firms' equilibrium output levels, x_1^{NR} and x_2^{NR}. Next, substituting x_2^{NR} into (11), and x_1^{NR} into (11), we obtain α_1^{NR} and α_2^{NR}, respectively. Finally, substituting these equilibrium actions into (10), we obtain the firms' equilibrium profits, π_1^{NR} and π_2^{NR}, in the (*NR*, *NR*) subgame.

Lemma 3 summarizes the outcomes of the (*NR*, *NR*) subgame:

Lemma 3. (*a*) *In the equilibrium of the* (*NR*, *NR*) *subgame*, *owner i*, *for* $i = 1, 2$, *chooses* $\alpha_i^{NR} = 1$, *and manager i chooses* $x_i^{NR} = (a-c)/3b$. (*b*) *The firms' equilibrium profits are* $\pi_1^{NR} = \pi_2^{NR} = (a-c)^2/9b$.

3.4. Firms' decisions on releasing their contract information

Now consider the firms' decisions on releasing their contract information at the beginning of the entire game. Each firm chooses and announces one of the following two actions: *R* or *NR*. We have four possible combinations of the actions that result from the firms' decisions: (*R*, *R*), (*R*, *NR*), (*NR*, *R*), and (*NR*, *NR*).

Figure 1 shows the profits of the firms that will be realized under the four possible combinations. (*R*, *R*) leads to the (*R*, *R*) subgame analyzed in Section 3.1, so that firm *i*'s profits at the end of the game will be π_i^R, for $i = 1, 2$, in Lemma 1. (*R*, *NR*) (resp. (*NR*, *R*)) leads to the (*R*, *NR*) subgame (resp. the (*NR*, *R*) subgame) analyzed in Section 3.2, so that firm *i*'s profits at the end of the game will be π_i^{1R} (resp. π_i^{2R}) in Lemma 2. Finally, (*NR*, *NR*) leads to the (*NR*, *NR*) subgame analyzed in Section 3.3, so that firm *i*'s profits at the end of the game will be π_i^{NR} in Lemma 3.

Which combination occurs in equilibrium? It is straightforward to obtain that: $\pi_1^R > \pi_1^{2R}$; $\pi_2^R > \pi_2^{1R}$; and $\pi_i^{iR} > \pi_i^{NR}$ for $i = 1, 2$. This implies that (*R*, *R*) occurs in equilibrium;

furthermore, *R* is each firm's dominant action: *R* leads to higher profits for each firm than *NR*, no matter what the other firm does.

Proposition 1. *Only the combination* (*R*, *R*) *occurs in equilibrium*.

The result that firm *i* chooses *R* regardless of the action it expects firm *j* to choose, for *i*, $j = 1, 2$ with $i \neq j$, can be explained as follows:

Consider first the case where firm *j* chooses *R*. Firm *i* has two options: either to choose *R* or to choose *NR*. If it chooses *R*, both firms will release their contract information. Then, firm *i* will compete with firm *j* on equal footing in the subsequent stages. On the other hand, if firm *i* chooses *NR*, only firm *j* will release its contract information and exercise strategic leadership. Then, firm *j* as the leader will choose and release a small value of α_j to make its manager aggressive in output competition, whereas firm *i* as the follower, sizing up firm *j*'s contract, will choose 1 as the value of α_i to avoid stiff output competition. As a result of this, firm *j*'s manager will choose a large output level, and firm *i*'s manager will choose a small output level, which will lead to lower profits for firm *i*, as compared to firm *i*'s choosing *R*. Hence, given firm *j*'s action *R*, firm *i* chooses *R*.

Next, consider the case where firm *j* chooses *NR*. In this case, too, firm *i* is better off by choosing *R* rather than *NR*. This is supported by the following explanation. With firm *j*'s action *NR* and its own action *R*, firm *i* will enjoy a first-mover advantage by releasing its contract information before firm *j* chooses its contract.[14] However, if firm *i* chooses *NR* instead of *R*, it will not have the strategic leadership and play a simultaneous-move game against firm *j*,

[14]In this case, as shown in Lemma 2, firm *i* as the leader chooses $\alpha_i = (5c - a)/4c$ and firm *j* as the follower chooses $\alpha_j = 1$. (Note that the firms' output levels are the same as those in the corresponding Stackelberg's model of duopoly.) Clearly, firm *i* makes its manager aggressive in output competition, as compared to firm *i*'s choosing *NR*. We may say that choosing *R* (or releasing contract information to the public) is an example of the top-dog strategy, which is defined by Fudenberg and Tirole (1984).

choosing two sequential actions without observing those chosen by firm j, which will result in smaller profits to firm i.

It is straightforward to see that there is no commitment problem (see Baik and Lee 2012). Indeed, each firm has no incentive to renege on the decision to release its contract information. To show this, suppose that firm i keeps its "promise" by choosing and releasing $\alpha_i = (6c - a)/5c$, as shown in Lemma 1, but firm j does not release its contract information. In this case, firm j chooses $\alpha_j = 1$ (see (5) and (6)). Then, using (5) and (7), we obtain $x_i = 7(a - c)/15b$, $x_j = 4(a - c)/15b$, and $\pi_j = 16(a - c)^2/225b$. Note, however, that if firm j keeps its promise by choosing and releasing $\alpha_j = (6c - a)/5c$, then its profits are $\pi_j = 2(a - c)^2/25b$, as shown in Lemma 1. This implies that firm j would be worse off by reneging on the decision to release its contract information.

Interestingly, Baik and Lee (2012) study a contest in which two groups compete to win a prize, and show that (R, R) never occurs, where R denotes the action of announcing that the sharing-rule information will be released. In contrast, Yildirim (2005) studies a two-player contest, and shows that the players announce that they will release the information about their period-1 effort levels.

3.5. The outcomes of the entire game

Let the superscript * indicate the equilibrium values of the variables. Using Proposition 1 and Lemma 1, we obtain the following outcomes of the game: First, both firms announce at the beginning of the game that they will release the information about their contracts. Second, firm i, for $i = 1, 2$, chooses and releases its contract, $\alpha_i^* = (6c - a)/5c$. Third, firm i chooses its output level, $x_i^* = 2(a - c)/5b$. Finally, firm i's profits (without subtracting its manager's compensation) are $\pi_i^* = 2(a - c)^2/25b$.

The value of α_i that firm i chooses is less than unity, which implies that firm i gives a positive weight to the sales component, S_i, in manager i's performance measure, O_i. By doing

so, firm i makes its manager more aggressive in the subsequent output competition, as compared with the case of profit maximization where $\alpha_i = 1$.

4. The model with price-setting firms

Consider a price-setting duopoly in which two firms, 1 and 2, produce and sell differentiated products. Each firm first announces whether or not to release to the public the information about its contract between the owner and the manager. Then, the owner of each firm writes – and releases if her firm announced to do so – a contract with her manager that specifies how the manager will be compensated. Finally, each manager chooses his firm's price.

The market demand function facing firm i is given by

$$q_i = d - hp_i + kp_j,$$

for $i, j = 1, 2$ with $i \neq j$, where q_i represents the quantity of firm i's product demanded, p_i represents firm i's price, p_j represents firm j's price, and d, h, and k are positive constants. We assume that $h > k > 0$. This assumption means that the effect of increasing p_i on q_i is greater than the effect of the same increase in p_j on q_i or, to put it differently, that the quantity of firm i's product demanded is more responsive to a change in firm i's price than to the same change in firm j's price.[15]

The cost function of firm i is given by $c(q_i) = cq_i$ for all $q_i \in R_+$, where $c(q_i)$ represents firm i's cost of producing q_i units of its product, and c represents a constant marginal cost to firm i. We assume that $0 < c < d/(h - k)$.

As in Section 2, we assume that manager i, for $i = 1, 2$, is induced to maximize

$$O_i = \alpha_i \pi_i + (1 - \alpha_i) S_i.$$

[15]With inverse market demand functions, this assumption is commonly stated as "the own-price effect dominates the cross-price effect" (see, for example, Shy 1995, pp. 135-136).

We assume also that owner i uses a compensation scheme in which manager i is paid $A_i + B_i O_i$, where A_i and B_i are constants with $A_i \geq 0$ and $B_i > 0$. Under this compensation scheme, as explained in Section 2, the contract that is designed by owner i provides manager i with equilibrium compensation that is exactly equal to his reservation wage R_i.

Given an incentive structure which is a linear combination of profits and sales, manager i, for $i = 1, 2$, seeks to maximize

$$O_i = p_i (d - hp_i + kp_j) - \alpha_i c (d - hp_i + kp_j). \tag{12}$$

On the other hand, we assume that each owner's objective is to maximize her firm's profits net of her manager's compensation. Mathematically, this amounts to assuming that owner i seeks to maximize her firm's profits

$$\pi_i = (p_i - c) (d - hp_i + kp_j), \tag{13}$$

because any contract that is designed by owner i provides manager i with equilibrium compensation exactly equal to his reservation wage R_i.

We formally consider the following game: First, each firm decides independently whether it will release its contract information to the public.[16] The firms simultaneously announce and commit to their decisions before writing their contracts. Next, the owner of each firm writes – and releases if her firm announced to do so – a contract with her manager. (We will be more specific about this stage in Section 5.) Finally, the managers choose their firms' prices simultaneously and independently.

We assume that all of the above is common knowledge among the owners and managers.

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[16]As in Section 2, we assume that each firm decides to release its contract information only if both the owner and the manager of the firm agree to do so. As explained in Section 2, this amounts to assuming that each firm's decision as to whether to release its contract information is made only by its owner.

5. The equilibrium decisions of the owners and managers

Working backward, we first analyze the four subgames that start after the firms announce whether they will release their contract information, and then consider the firms' decisions on releasing their contract information.

5.1. The (R, R) subgame

To solve for a subgame-perfect equilibrium of this subgame, we work backward. Lemma 4 summarizes the outcomes of the (*R*, *R*) subgame:

Lemma 4. (*a*) *In the equilibrium of the* (*R*, *R*) *subgame*, *owner i*, *for* $i = 1, 2$, *chooses* $\alpha_i^R = \{c(2h^2 - k^2)(2h - k) + dk^2\}/hc(4h^2 - 2hk - k^2)$, *and manager i chooses* $p_i^R = \{c(2h^2 - k^2) + 2dh\}/(4h^2 - 2hk - k^2)$. (*b*) *The firms' equilibrium profits are* $\pi_1^R = \pi_2^R = 2h(2h^2 - k^2)\{d - c(h - k)\}^2/(4h^2 - 2hk - k^2)^2$.

5.2. The (R, NR) subgame and the (NR, R) subgame

Consider a subgame in which firm *i* releases its contract information, but firm *j* does not, for $i, j = 1, 2$ with $i \neq j$. Note that we are considering the (*R*, *NR*) subgame if $i = 1$, and the (*NR*, *R*) subgame if $i = 2$. We assume that firm *j* chooses its contract after observing firm *i*'s contract.

We solve the subgame by viewing it as the following two-stage game: In the first stage, owner *i* chooses and releases a value of α_i. In the second stage, after observing the value of α_i, manager *i* and firm *j* play a simultaneous-move game. Specifically, manager *i* chooses his firm's price, without observing the value of α_j or firm *j*'s price; owner *j* chooses a value of α_j, and manager *j* (after observing the value of α_j) chooses his firm's price; both actions occur without either *j* entity's observing firm *i*'s price.

To solve this two-stage game, we work backward: In the second stage, manager *i* and firm *j* know the value of α_i. We begin by deriving the reaction function for manager *i*. After

observing α_i, manager *i* seeks to maximize O_i in (12) over his firm's price p_i, taking firm *j*'s price p_j as given. From the first-order condition for maximizing O_i, we obtain manager *i*'s reaction function:

$$p_i(p_j; \alpha_i) = (d + \alpha_i hc + kp_j)/2h. \tag{14}$$

Next, consider firm *j*. Owner *j* chooses a value of α_j, and then manager *j* chooses his firm's price; both actions occur without either *j* entity's observing firm *i*'s price. Working backward, we first consider manager *j*'s decision on his firm's price. After observing the values of α_1 and α_2, manager *j* seeks to maximize O_j in (12) over his firm's price p_j, taking firm *i*'s price p_i as given. From the first-order condition for maximizing O_j, we obtain manager *j*'s reaction function:

$$p_j(p_i; \alpha_1, \alpha_2) = (d + \alpha_j hc + kp_i)/2h. \tag{15}$$

Then, we consider owner *j*'s decision on the value of α_j. Owner *j* seeks to maximize

$$\begin{aligned} \pi_j(p_i, \alpha_j; \alpha_i) &= \{p_j(p_i; \alpha_1, \alpha_2) - c\}\{d - hp_j(p_i; \alpha_1, \alpha_2) + kp_i\} \\ &= (d + \alpha_j hc + kp_i - 2hc)(d - \alpha_j hc + kp_i)/4h \end{aligned} \tag{16}$$

with respect to α_j, taking firm *i*'s price p_i as given. Note that we obtain (16) by substituting (15) into (13). From the first-order condition for maximizing (16), we obtain another reaction function of firm *j*, or owner *j*'s reaction function:

$$\alpha_j(p_i; \alpha_i) = 1. \tag{17}$$

By solving the system of three simultaneous equations, (14), (15), and (17), we obtain

$$\begin{aligned} p_i(\alpha_i) &= \{d(2h + k) + hc(2\alpha_i h + k)\}/(4h^2 - k^2); \\ p_j(\alpha_i) &= \{d(2h + k) + hc(2h + \alpha_i k)\}/(4h^2 - k^2); \\ \text{and} \quad \alpha_j(\alpha_i) &= 1. \end{aligned} \tag{18}$$

These are the equilibrium price of firm i, that of firm j, and the equilibrium value of α_j, respectively, in the second stage.

Next, consider the first stage in which owner i chooses a value of α_i. Having perfect foresight about $\pi_i(\alpha_i)$ for any values of α_i, owner i chooses a value of α_i that maximizes

$$\pi_i(\alpha_i) = \{d(2h+k) + c(hk - 4h^2 + k^2) + 2\alpha_i h^2 c\} \times \{dh(2h+k) - \alpha_i hc(2h^2 - k^2) + h^2 kc\}/(4h^2 - k^2)^2. \quad (19)$$

Note that we obtain (19) by substituting $p_i(\alpha_i)$ and $p_j(\alpha_i)$ in (18) into (13). From the first-order condition for maximizing (19) with respect to α_i, we obtain the equilibrium value of α_i in the subgame:

$$\alpha_i^{iR} = [dk^2(2h+k) + c\{hk^3 + (4h^2 - k^2)(2h^2 - k^2)\}]/4h^2 c(2h^2 - k^2).$$

Now, substituting α_i^{iR} into $p_i(\alpha_i)$, $p_j(\alpha_i)$, and $\alpha_j(\alpha_i)$ in (18), we obtain the firms' equilibrium prices – p_i^{iR} and p_j^{iR} – and the equilibrium value of α_j, which is denoted by α_j^{iR}, in the subgame. Next, using these equilibrium actions, we obtain the firms' equilibrium profits – π_1^{iR} and π_2^{iR} – in the subgame.

Lemma 5 summarizes the outcomes of the (R, NR) subgame if $i = 1$, and those of the (NR, R) subgame if $i = 2$:

Lemma 5. (a) *In the equilibrium of a subgame in which firm i releases its contract information, but firm j does not, for i, j = 1, 2 with i ≠ j, owner i chooses* $\alpha_i^{iR} = [dk^2(2h+k) + c\{hk^3 + (4h^2 - k^2)(2h^2 - k^2)\}]/4h^2 c(2h^2 - k^2)$, *and manager i chooses* $p_i^{iR} = \{d(2h+k) + c(2h^2 - k^2 + hk)\}/2(2h^2 - k^2)$. *Owner j chooses* $\alpha_j^{iR} = 1$, *and manager j chooses* $p_j^{iR} = [d(4h^2 - k^2 + 2hk) + c\{h(4h^2 - k^2) + k(2h^2 - k^2)\}]/4h(2h^2 - k^2)$.

(b) *The equilibrium profits of firm i and those of firm j are* $\pi_i^{iR} = (2h+k)^2\{d - c(h-k)\}^2/8h(2h^2 - k^2)$ *and* $\pi_j^{iR} = \{d(4h^2 - k^2 + 2hk) + hc(3k^2 - 4h^2) + kc(2h^2 - k^2)\}^2/16h(2h^2 - k^2)^2$, *respectively*.

5.3. The (NR, NR) subgame

The equilibrium values of α_1 and α_2 and the equilibrium prices of the firms in the subgame satisfy the following two requirements: First, firm *i*'s price is optimal given the value of α_i and given firm *j*'s price, for $i, j = 1, 2$ with $i \neq j$. Second, the value of α_i is optimal given firm *j*'s price and given firm *i*'s own subsequent optimal behavior: its optimal price.

To obtain the equilibrium values of α_1 and α_2 and the equilibrium prices of the firms, we begin by deriving the reaction functions for firm *i*. Working backward, we first consider manager *i*'s decision on his firm's price. After observing the value of α_i, manager *i* seeks to maximize O_i in (12) over his firm's price p_i, taking firm *j*'s price p_j as given. From the first-order condition for maximizing O_i, we obtain manager *i*'s reaction function:

$$p_i(p_j; \alpha_i) = (d + \alpha_i hc + kp_j)/2h. \tag{20}$$

Then, we consider owner *i*'s decision on the value of α_i. Owner *i* seeks to maximize

$$\pi_i(p_j, \alpha_i) = (d - 2hc + kp_j + \alpha_i hc)(d + kp_j - \alpha_i hc)/4h \tag{21}$$

with respect to α_i, taking firm *j*'s price p_j as given. Note that we obtain (21) by substituting (20) into (13). From the first-order condition for maximizing (21), we obtain another reaction function of firm *i*, or owner *i*'s reaction function:

$$\alpha_i(p_j) = 1. \tag{22}$$

We are now ready to obtain the firms' equilibrium actions, denoted by (α_1^{NR}, p_1^{NR}, α_2^{NR}, p_2^{NR}), by solving the system of four simultaneous equations, which comes from (20) and (22). Substituting (22) into (20), we have

$$p_1(p_2) = (d + hc + kp_2)/2h;$$

and

$$p_2(p_1) = (d + hc + kp_1)/2h.$$

By solving this pair of simultaneous equations, we obtain the firms' equilibrium prices, p_1^{NR} and p_2^{NR}. Next, substituting p_2^{NR} into (22), and p_1^{NR} into (22), we obtain α_1^{NR} and α_2^{NR}, respectively. Finally, substituting these equilibrium actions into (21), we obtain the firms' equilibrium profits, π_1^{NR} and π_2^{NR}, in the (*NR*, *NR*) subgame.

Lemma 6 summarizes the outcomes of the (*NR*, *NR*) subgame:

Lemma 6. (*a*) *In the equilibrium of the* (*NR*, *NR*) *subgame*, *owner i*, *for* $i = 1, 2$, *chooses* $\alpha_i^{NR} = 1$, *and manager i chooses* $p_i^{NR} = (d + hc)/(2h - k)$. (*b*) *The firms' equilibrium profits are* $\pi_1^{NR} = \pi_2^{NR} = h\{d - c(h - k)\}^2/(2h - k)^2$.

5.4. Firms' decisions on releasing their contract information

At the beginning of the entire game, each firm chooses and announces one of the following two actions: *R* or *NR*. We have four possible combinations of the actions resulting from the firms' choices: (*R*, *R*), (*R*, *NR*), (*NR*, *R*), and (*NR*, *NR*). Figure 2 shows the profits of the firms that will be realized under these four possible combinations (see Lemmas 4 through 6).

After some algebra, we obtain that $\pi_1^R > \pi_1^{2R}$, $\pi_2^R > \pi_2^{1R}$, and $\pi_i^{iR} > \pi_i^{NR}$ for $i = 1, 2$. These comparison results can be explained graphically in terms of the managers' reaction functions. For example, consider the comparison result that $\pi_1^{1R} > \pi_1^{NR}$. First, recall from Lemma 6 that $\alpha_i^{NR} = 1$, for $i = 1, 2$, in the (*NR*, *NR*) subgame. In this case, the upward-sloping reaction functions of the managers intersect at (p_1^{NR}, p_2^{NR}) in the p_1p_2-space, where $p_1^{NR} = p_2^{NR}$ (see Sklivas 1987, p. 456), and firm 1 earns the profits, π_1^{NR}. Next, recall from Lemma 5 that $\alpha_1^{1R} > 1$ and $\alpha_2^{1R} = 1$ in the (*R*, *NR*) subgame. In this case, the upward-sloping reaction function of manager 1 shifts outward in the p_1p_2-space, while the upward-sloping reaction function of manager 2 stays put, as compared with the (*NR*, *NR*) subgame. This entails that the managers choose higher prices, compared to the (*NR*, *NR*) subgame, at the intersection of these new reaction functions: $p_1^{1R} > p_1^{NR}$ and $p_2^{1R} > p_2^{NR}$. Finally, these higher prices of both firms result in higher profits to firm 1 in the (*R*, *NR*) subgame: $\pi_1^{1R} > \pi_1^{NR}$.

The comparison results obtained in the preceding paragraph imply that (R, R) occurs in equilibrium; furthermore, R is each firm's dominant action.

Proposition 2. *Only the combination* (R, R) *occurs in equilibrium*.

Proposition 2 states – as does Proposition 1 – that both firms announce at the beginning of the entire game that they will release their contract information. The explanations for Proposition 2 may be made similarly to those for Proposition 1, and therefore are omitted.

5.5. The outcomes of the entire game

Let the superscript ** indicate the equilibrium values of the variables. Using Proposition 2 and Lemma 4, we obtain the following outcomes of the game: First, both firms announce at the beginning of the game that they will release the information about their contracts. Second, firm i, for $i = 1, 2$, chooses and releases its contract, $\alpha_i^{**} = \{c(2h^2 - k^2)(2h - k) + dk^2\} / hc(4h^2 - 2hk - k^2)$. Third, firm i chooses its price, $p_i^{**} = \{c(2h^2 - k^2) + 2dh\} / (4h^2 - 2hk - k^2)$. Finally, firm i's profits (without subtracting its manager's compensation) are $\pi_i^{**} = 2h(2h^2 - k^2)\{d - c(h - k)\}^2 / (4h^2 - 2hk - k^2)^2$.

The value of α_i that firm i chooses is greater than unity, which implies that firm i gives a negative weight to the sales component, S_i, in manager i's performance measure, O_i. By doing so, firm i makes its manager less aggressive in the subsequent price competition, as compared with the case of profit maximization where $\alpha_i = 1$. To understand this result, note first that the managers' reaction functions are upward-sloping in the p_1p_2-space (see Sklivas 1987, p. 456). Then, note that, if the firms motivate their managers to be less aggressive – so that the managers' reaction functions shift outward or upward – as compared with the case of profit maximization, then both managers choose higher prices, and thus both firms earn higher profits.

6. A comparison: observable versus unobservable contracts

Let the superscripts *oc* and *uc* indicate the outcomes of the observable-contracts case and those of the unobservable-contracts case, respectively.[17] Several outcomes of the observable-contracts case are provided in Lemma 1 for the quantity-setting firms, and in Lemma 4 for the price-setting firms. On the other hand, the corresponding outcomes of the unobservable-contracts case are provided in Lemma 3 for the quantity-setting firms, and in Lemma 6 for the price-setting firms. Let CS represent the consumer surplus, and let W represent welfare, defined as the simple sum of the consumer surplus and the firms' profits.

Lemma 7. (*a*) *For the quantity-setting firms, we obtain:* $CS^{oc} = 8(a-c)^2/25b$, $CS^{uc} = 2(a-c)^2/9b$, $W^{oc} = 12(a-c)^2/25b$, *and* $W^{uc} = 4(a-c)^2/9b$. (*b*) *For the price-setting firms, we obtain:* $CS^{oc} = (2h^2-k^2)^2\{d-c(h-k)\}^2/h(4h^2-2hk-k^2)^2$, $CS^{uc} = h\{d-c(h-k)\}^2/(2h-k)^2$, $W^{oc} = (2h^2-k^2)(6h^2-k^2)\{d-c(h-k)\}^2/h(4h^2-2hk-k^2)^2$, *and* $W^{uc} = 3h\{d-c(h-k)\}^2/(2h-k)^2$.

We compare the outcomes of the observable-contracts case with those of the unobservable-contracts case. The comparison results are reported in Proposition 3.

Proposition 3. (*a*) *For the quantity-setting firms, we obtain for* $i = 1, 2$*:* $\alpha_i^{oc} < \alpha_i^{uc}$, $x_i^{oc} > x_i^{uc}$, $\pi_i^{oc} < \pi_i^{uc}$, $CS^{oc} > CS^{uc}$, *and* $W^{oc} > W^{uc}$. (*b*) *For the price-setting firms, we obtain for* $i = 1, 2$*:* $\alpha_i^{oc} > \alpha_i^{uc}$, $p_i^{oc} > p_i^{uc}$, $\pi_i^{oc} > \pi_i^{uc}$, *and* $CS^{oc} < CS^{uc}$. *We also obtain that* $W^{oc} > W^{uc}$ *if* $k < h < \min\{1.9297k, k + d/c\}$.[18]

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[17]Recall from Section 1 that the observable-contracts (unobservable-contracts) case is the one where each firm's contract is *exogenously* assumed to be observable (unobservable) to the rival firm. In the two models we have so far considered, we have established that both firms release their contract information. This implies that the outcomes of each of the two models are exactly the same as those of the corresponding observable-contracts case.

[18]Note that $W^{oc} > W^{uc}$ if $-8\theta^4 + 20\theta^3 - 7\theta^2 - 4\theta + 1 > 0$, where $\theta = h/k$. Note also that $0 < k < h < k + d/c$ under the assumptions in Section 4.

The following complements part (b) in the case where $k + d/c \geq 1.9297k$: $W^{oc} < W^{uc}$ if $1.9297k \leq h < k + d/c$.

Each quantity-setting firm makes its manager more aggressive in the observable-contracts case than in the unobservable-contracts case. This results in greater output levels, lower profits of the firms, and greater consumer surplus in the observable-contracts case. By contrast, each price-setting firm makes its manager less aggressive in the observable-contracts case than in the unobservable-contracts case. This results in higher prices, higher profits for the firms, and lower consumer surplus in the observable-contracts case.

The welfare that results from the observable-contracts case is always greater than the welfare that results from the unobservable-contracts case, in the quantity-setting market. Similarly, in the price-setting market, W^{oc} is greater than W^{uc} unless the ratio of h to k is large. This welfare comparison result in the price-setting market can be explained as follows: First, under the definitions, $W^{oc} = 2\pi_i^{oc} + CS^{oc}$ and $W^{uc} = 2\pi_i^{uc} + CS^{uc}$, it implies that two times the profits gap between the two cases, $2(\pi_i^{oc} - \pi_i^{uc})$, outweighs the consumer surplus gap between the two cases, $(CS^{uc} - CS^{oc})$, unless the ratio of h to k is large. Second, it may occur that W^{oc} is less than W^{uc}. In fact, if $k + d/c \geq 1.9297k$, then $W^{oc} < W^{uc}$ if $1.9297k \leq h < k + d/c$. In this case, the consumer surplus gap between the two cases – $(CS^{uc} - CS^{oc})$ – outweighs two times the profits gap between the two cases, $2(\pi_i^{oc} - \pi_i^{uc})$. Indeed, given that $k + d/c \geq 1.9297k$, if the ratio of h to k is large, so that the own-price effect is, in relative terms, significantly greater than the cross-price effect, then $(CS^{uc} - CS^{oc})$ is greater than $2(\pi_i^{oc} - \pi_i^{uc})$ (see footnote 15).

7. A modification: more than two firms

We briefly consider a modified model in which there are n quantity-setting firms, and also one in which there are n price-setting firms, where $n \geq 3$. The first modified model is the same as the model in Section 2 with the exception that the number of firms is now larger. The second modified model is the same as the model in Section 4 with the exception that the number

of firms is now larger, and the market demand function facing firm i, for $i = 1, \ldots, n$, is now replaced with[19]

$$q_i = d - hp_i + k\sum_{j \neq i} p_j.$$

Because of computational complexities involved, we may not complete the full analyses of these two modified models. However, we find in both modified models that there exists an equilibrium in which every firm announces at the beginning of the game that it will release its contract information, and actually releases the information.

8. Conclusions

We have studied duopolies in which firms – each of which consists of an owner and a manager – have the option of releasing or not their contract information between the owner and the manager. Formally, we have considered the following game: First, each firm decides and announces whether it will release its contract information to the public. Next, the owner of each firm writes – and releases if her firm announced to do so – a contract with her manager. Finally, the managers in both firms choose values of the strategic variable, quantity or price, simultaneously and independently.

As a main result, we have shown that each firm announces that it will release its contract information – regardless of the action that it expects the rival firm to take – and actually does release it. Then, comparing the outcomes of the observable-contracts case with those of the unobservable-contracts case, we have shown that the welfare that results from the observable-contracts case is generally (but not always) greater than that resulting from the unobservable-contracts case.

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[19]For demand systems with product differentiation, see Vives (1999, pp. 144-148).

In the models we have considered in this paper, we have assumed that the firms have the same marginal cost of production. Instead, we could assume that they have different marginal costs. With this modification, we obtain exactly the same main results.

In the models of this paper, each firm's decision on releasing its contract information is, in effect, made by its owner because its manager is indifferent between releasing and not releasing the contract information. One may obtain different results with a model in which each firm's decision on releasing its contract information is, in effect, made by both its owner and its manager or only by its manager. Another possible modification of this paper would be to consider quantity-setting and price-setting models in both of which there is asymmetric information between each firm's owner and its manager. We leave these modifications for future research.

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Firm 2

Firm 1	*R*	*NR*
R	$\pi_2^R = \frac{2(a-c)^2}{25b}$ $\pi_1^R = \frac{2(a-c)^2}{25b}$	$\pi_2^{1R} = \frac{(a-c)^2}{16b}$ $\pi_1^{1R} = \frac{(a-c)^2}{8b}$
NR	$\pi_2^{2R} = \frac{(a-c)^2}{8b}$ $\pi_1^{2R} = \frac{(a-c)^2}{16b}$	$\pi_2^{NR} = \frac{(a-c)^2}{9b}$ $\pi_1^{NR} = \frac{(a-c)^2}{9b}$

Figure 1. The Profits of the Quantity-Setting Firms

Firm 1 \ Firm 2	R	NR
R	$\pi_2^R = \frac{2h(2h^2-k^2)\{d-c(h-k)\}^2}{(4h^2-2hk-k^2)^2}$ $\pi_1^R = \frac{2h(2h^2-k^2)\{d-c(h-k)\}^2}{(4h^2-2hk-k^2)^2}$	$\pi_2^{1R} = \frac{\{d(4h^2-k^2+2hk)+hc(3k^2-4h^2)+kc(2h^2-k^2)\}^2}{16h(2h^2-k^2)^2}$ $\pi_1^{1R} = \frac{(2h+k)^2\{d-c(h-k)\}^2}{8h(2h^2-k^2)}$
NR	$\pi_2^{2R} = \frac{(2h+k)^2\{d-c(h-k)\}^2}{8h(2h^2-k^2)}$ $\pi_1^{2R} = \frac{\{d(4h^2-k^2+2hk)+hc(3k^2-4h^2)+kc(2h^2-k^2)\}^2}{16h(2h^2-k^2)^2}$	$\pi_2^{NR} = \frac{h\{d-c(h-k)\}^2}{(2h-k)^2}$ $\pi_1^{NR} = \frac{h\{d-c(h-k)\}^2}{(2h-k)^2}$

Figure 2. The Profits of the Price-Setting Firms