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Optimal collective reputation

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ABSTRACT

Collective reputation, such as watches “made in Switzerland”, affects the whole industry all over the world. This article highlights the relationship between competition and collective reputation. First, collective quality level depends on firms objectives. Second, the collectively determined quality of profit incentive firms reaches social optimal level. Finally, quality restriction is more efficient than subsidies to promote collective quality. The policy implication is that antitrust policy should not care about jointly determined quality for profit incentive firms. Further, cooperative innovation is encouraged to promote the collective reputation or cooperative innovation promotes the values of patents by collective reputation.

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Collective reputation;
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1. Introduction

Collective reputation is shaped by collective firms and the name is used by all related firms in general. Collective reputation popularly exists all over the world and has crucial effects on some industries and national economy (Ingenhoff et al., 2018). For example, “Made in Japan” meant high quality all over the world before 2017. Kobe Steel LTD (KOBELCO), established in 1905, is the third steel firm and has 7,000 suppliers across Japan, most of which are small and medium-sized companies. Moreover, KOBELCO is the top Japanese manufacturer of aluminum can stock, and two out of every three bottle cans are made of Kobe Steel’s aluminum material. On October of 2017, KOBELCO admitted that besides aluminum, copper, steel powder and special steels, its thick plates processed at a subsidiary had also been found with fabricated data. The reputation of Japanese metals manufacturing has been dealt a heavy blow. Production made in Japan is thrown doubt and collective reputation is seriously destroyed (http://www.chinadaily.com.cn/kindle/2017-10/12/content_33160359.htm).

Because of fierce competition, Kobe Steel launched fabricated data. Kobe Steel’s scandal is a blow to “Made-in-Japan”. Therefore, it is crucial to keep collective quality under competitive environment. This article aims to answer the following three questions: (1) What is the collective quality level affected? (2) Does the collective quality by firms’ joint decision observe antitrust policy? (3) How to improve collective quality?

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To answer the above three questions, this article establishes game theory model. By analysis, the equilibrium quality depends on the firms' objective. Moreover, joint decision about quality observes antitrust rules. Finally, governmental intervention can improve collective quality. Moreover, the quality restriction seems more efficient than others.

The contributions of this article lie in two aspects. On one hand, the theory of collective reputation is further developed. This article argues that collective reputation improves the quality to access the social optimal level. This result further shows the importance of collective reputation. On the other hand, this article supports decision for firms and authority. This article suggests firms to establish collective reputation in production. Further, government is encouraged to support firms to form collective reputation.

The rest of this article is organized as follows: Literature review is given in [Section 2](#). Model is established in [Section 3](#). The model is analyzed in [Section 4](#). Further discussion is presented in [Section 5](#). In this section, social optimal quality is addressed. Conclusions are remarked in the final section.

2. Literature review

Collective reputation is initially proposed by Klein and Leffler (1981). Klein and Leffler (1981) found that reputation or brand name support strong incentive to guarantee contract performance. Then, the theory of collective reputation is developed. Tirole (1996) first established mathematical model to address collective reputation. Tirole (1996) argued that either the equilibrium with high corruption or one with low corruption exists. Moreover, under asymmetric case, Tirole (1996) showed that a large firm plays important role to maintain collective reputation. Neeman et al. (2019) recently developed theory of collective reputation with game theory model, and they showed that firms have intention of free-rider in long turn and intention of milking in short term. Levin (2009) extended collective reputation to dynamic situations. Kim and Loury (2018) developed empirical approaches for collective reputation. Agarwal et al. (2018) checked the scale of collective reputation. Harper et al. (2021) simulated collective reputation and argued that trust plays important roles in the society.

Collective reputation affects productions, advertisement, quality, price and demand. Zhang et al. (2019) highlighted the effects of collective reputation on new product development and argued that the quality of new product depends on the strategy selection. Mas-Ruiz et al. (2016) identified that a firm with collective brand has greater advertising productivity than others. Sellers-Rubio et al. (2018) further confirmed the conclusions of Mas-Ruiz et al. (2016) with data of wine industry. Fishman et al. (2018) recently developed the quality theory under collective reputation. Fontini et al. (2018) identified the price of collective reputation goods under stochastic situation. Hook et al. (2020) investigated the effects of collective reputation on demands for children's brand.

Based on the theory of collective reputation, the establishment of collective reputation is highlighted in recent years. On one hand, both Valasek (2018) and Ravasi et al. (2018) focused on the establishment of collective reputation by public institution reform and management, respectively. Etter et al. (2019) further pointed out that social media help to

establish collective reputation. On the other hand, Breitinger and Bonardi (2019) examined factors to destroy collective reputation.

In applications of collective reputation, collective reputation is widely used to address food quality (Saak, 2012; Scarpa et al., 2008; Winfree & McCluskey, 2005), platform firms (Berkowitz & Souchaud, 2019; Winfree & McCluskey, 2020), energy environment (Ahlin et al., 2021; Truong et al., 2021) and so on (Chen et al., 2020; Nie et al., 2018, 2021). In food industry, Saak (2012) argued that public monitoring help firms earn high profits. Winfree and McCluskey (2005) showed that local firms resort to collective reputation and suggested minimum quality standard. About platform firms, Winfree and McCluskey (2020) proposed minimum quality standard in online platform. Berkowitz and Souchaud (2019) also stressed the important of regulation and self-regulation to guarantee the collective quality in sharing economy. Kim et al. (2021) argued that collective reputation establishes the relationship between environment and firms' performance. Nie et al. (2021) addresses the reputation of durable goods.

Both in theory and in application of collective reputation, no literature touches the relationship between competition and collective reputation. Actually, collective reputation rarely exists in the industry with fierce competition. Therefore, it is important to capture the effects of competition on collective reputation. This article aims to investigate the relationship between competition and collective reputation.

3. Model establishment

Here, we establish the mathematic model to address the collective reputation under oligopoly. Assume N firms in some industry to produce the identical goods with the quality κ , $\kappa \in (0, 1]$ and the outputs q_i , $i \in \{1, 2, \dots, N\}$. Given the price p and the total supply $q = q_1 + q_2 + \dots + q_N$, the inverse demand in this industry is given as follows

$$p = A(1 + \kappa) - q, \quad (1)$$

where $A > 0$ is the basic market size without brand effects. The market size is increasing with the quality of brand value. This assumption is generally employed in many other papers (Nie & Sun, 2015; Wang et al., 2019). The linear demand is utilized to simplify the model (Nie & Wang, 2019). It is easy to extend to general situation and the corresponding analysis becomes complicated.

For firm i , $i \in \{1, 2, \dots, N\}$, allowed for the collective product quality κ , the profits are given as follows

$$\pi_i = pq_i - c_0(1 + \kappa)q_i - F(1 + \kappa). \quad (2)$$

In (2), $c_0 > 0$ is constant and $F \geq 0$ is the sunken cost with the lowest quality. In the right of (2), the first term means the revenues, the second is the costs incurred by production and the third is the sunken costs related with collective quality. We assume that both the marginal cost and sunken costs are closely related to the quality. Higher quality manifests higher marginal and sunken costs, which is also consistent with the reality in production. In general, higher quality productions require higher production costs and more sunken

costs. This is also consistent with the reality. For the collective reputation in the above model, to simplify, the linear effects on the price are assumed. Moreover, on one hand, collective reputation can promote the utility and price. On the other hand, high collective reputation requires high costs. Therefore, it is exceedingly important to select equilibrium collective reputation

The timing of this game is listed as follows: In the first stage, firms jointly determine the quality of the products. In the second stage, all firms produce the identical productions based on the quality and the quality of each firm is known by others.

4. Model analysis

Here, the above model is addressed. The model is investigated by backward induction approach. We calculate the second stage, then the first stage. Based on different targets, firms determine the various collective quality levels in the first stage.

In the second stage, objective function is concave and the unique solution exists. Given the quality, the equilibrium outputs are determined by the following first-order optimal conditions

$$\frac{\partial \pi_i}{\partial q_i} = (A - c_0)(1 + \kappa) - q_i - \sum_{j=1}^N q_j = 0. \quad (3)$$

By the symmetry, we have

$$q_i = \frac{(A - c_0)(1 + \kappa)}{N + 1}. \quad (4)$$

The corresponding profits are $\pi_i = \frac{(A - c_0)^2(1 + \kappa)^2}{(N + 1)^2} - F(1 + \kappa)$.

4.1. Collective quality to deter entrants

The first stage is then addressed. In the first stage, firms jointly determine the quality of collective reputation. The determined quality depends on the target of firms. Here, we address the quality to deter the potential entrants. Then, the following conditions are satisfied

$$\begin{aligned} \pi_i &= \frac{(A - c_0)^2(1 + \kappa)^2}{(N + 1)^2} - F(1 + \kappa) > 0, \\ \frac{(A - c_0)^2(1 + \kappa)^2}{(N + 2)^2} - F(1 + \kappa) &\leq 0. \end{aligned} \quad (5)$$

The first inequality means the positive profits in this industry. According to the second inequality of (5), if one more firm enters into this industry, all firms share non-positive profits. The above inequalities are rewritten as follows

$$\frac{F(N+2)^2}{(A-c_0)^2} - 1 \geq \kappa^{*,1} > \frac{F(N+1)^2}{(A-c_0)^2} - 1. \quad (6)$$

Thus, the optimal quality to deter the potential entrants is determined by (6). The corresponding outputs, profits and price are

$$\begin{aligned} q_i^{*,1} &= \frac{(A-c_0)(1+\kappa^{*,1})}{N+1}, \\ \pi_i^{*,1} &= \frac{(A-c_0)^2(1+\kappa^{*,1})^2}{(N+1)^2} - F(1+\kappa^{*,1}), \\ p^{*,1} &= \frac{A(1+\kappa^{*,1})}{N+1} + \frac{Nc_0(1+\kappa^{*,1})}{N+1}. \end{aligned} \quad (7)$$

Therefore, the above analysis is summarized as follows

Proposition 1 To deter potential entrants, the optimal quality is given by (6) and the outputs, profits and price are determined by (7).

Remarks: On one hand, joint quality can deter the potential entrants. On the other hand, (6) supports the range of firms' joint quality to deter potential entrants. Apparently, both sunken costs and production cost promote the collective quality, while the market size reduces the joint quality. Moreover, given collective quality, the optimal number of firms in this industry is

$N = \text{int}\left(\sqrt{\frac{(1+\kappa^{*,1})(A-c_0)^2}{F}} - 1\right)$ (The above function means the integer part of the corresponding value). The optimal number of incumbents in this industry decreases with the sunken costs, while increases with the market size.

As an extreme case, under free entry or $F = 0$, all firms have chance to enter into this industry. When consumers have no experience to identify the quality, firms are inclined to low quality products. This industry will be occupied by low quality productions and the collective reputation is destroyed. Thus, high sunken costs, acting as a commitment, guarantee high quality. Moreover, under fierce competitive environment, it is very difficult to monitor the quality of productions. Therefore, under free entry, it is difficult to establish collective reputation.

For the outputs and price, higher sunken costs yield both more output and higher price. Because higher sunken costs improve both the costs of production and the market size, higher costs yield higher price and larger market size brings about more outputs. Therefore, sunken costs have stimulating effects on both outputs and price.

In summary, sunken costs play crucial role to determinate the potential entrants under collective quality. The policy implication is to launch lowest quality restriction or assess regulation (to improve sunken costs) to guarantee the production quality in this industry.

4.2. Collective quality to maximize profits

We further consider the situation without potential entrants. In this case, firms select collective quality to maximize the profits. The profit function is convex in the quality. We therefore have the optimal quality $\kappa^{*,2} = 1$ because of the following relationship $\frac{4(A-c_0)^2}{(N+1)^2} - 2F > \frac{(A-c_0)^2}{(N+1)^2} - F$. The corresponding outputs, profits and price are then listed as follows

$$\begin{aligned} q_i^{*,2} &= \frac{2(A-c_0)}{N+1}, \\ \pi_i^{*,2} &= \frac{4(A-c_0)^2}{(N+1)^2} - 2F, \\ p^{*,2} &= \frac{2A}{N+1} + \frac{2Nc_0}{N+1}. \end{aligned} \quad (8)$$

The above analysis is summarized as follows

Proposition 2 Profit incentive firms produce the highest quality production.

Remarks: Under profit incentive firms, firms' profits are monotonically increased with production quality. Therefore, firms jointly select the highest quality production, because (8) manifests that quality improves both price and demand. Or, quality has stimulating effects on both the price and the market size. By this way, firms' profits are correspondingly promoted. To maximize the profits, profit incentive firms select the highest quality.

5. Further discussion

It is very important to determine how to select collective quality in an industry. Industrial association is a very popular nongovernmental organization to establish quality criterion and collective quality. In general, the corresponding industrial association owns both academic knowledge about production quality and good reputation in the society. This industrial association constructs the quality criterion to determine the collective quality. The industrial association can overcome asymmetric information about quality to a certain degree. Some regions use governmental intervention to regulate and testify the collective quality. In summary, both formal and informal governance exist to establish collective quality.

This article does not care about the collective quality criterion and the antitrust about collective quality is focused. This article considers antitrust by examining social welfare. Here, we consider the social optimal quality. The model is also addressed by backward induction strategy. The second stage is the same as [Section 4](#). In the first stage, firms jointly maximize the social welfare by the collective quality as follows:

$$SW = \frac{N[(A-c_0)(1+\kappa)]^2}{N+1} \frac{N+2}{2(N+1)} - NF(1+\kappa). \quad (9)$$

(9) is also convex in quality and the social optimal quality is given by $\kappa^{*,3} = 1$. Therefore, the social optimal quality is exact the profit incentive quality or the highest quality. The corresponding outputs, profits and price are the same as (8), which is denoted as

$$\begin{aligned} q_i^{*,3} &= \frac{2(A-c_0)}{N+1}, \\ \pi_i^{*,3} &= \frac{4(A-c_0)^2}{(N+1)^2} - 2F, \\ p^{*,3} &= \frac{2A}{N+1} + \frac{2Nc_0}{N+1}. \end{aligned} \quad (10)$$

The equilibrium under social optimality owns the properties of collectively determined optimal quality. Based on the above analysis, we have the following conclusion

Proposition 3 The collective quality determined by profit incentive firms reaches social optimal level.

Remarks: Profit incentive firms jointly determine collective quality, the highest quality is achieved because improving quality promotes both consumer surplus and producer plus. When the quality reaches the highest, both the consumer surplus and the producer surplus also reach the most. Therefore, collective quality can reach the social optimal level. In summary, the collective quality jointly determined by profit incentive firms does not violate antitrust law or policies. Moreover, collective reputation encourages cooperative innovation and the corresponding patent values are promoted by collective reputation (Nie et al., 2022, 2023a, 2023b).

We further consider the optimal number of firms in this industry under social optimal collective quality. The optimal number of firm N^* satisfies the relationship

$$\frac{4(A-c_0)^2}{(N^*+1)^2} - 2F > 0, \frac{4(A-c_0)^2}{(N^*+2)^2} - 2F < 0. \quad (11)$$

(10) is restated as

$$\frac{2(A-c_0)}{\sqrt{2F}} - 2 < N^* < \frac{2(A-c_0)}{\sqrt{2F}} - 1. \quad (12)$$

Thus, the optimal number of firms is $\text{Int}[\frac{2(A-c_0)}{\sqrt{2F}} - 1]$. (The function $\text{Int}()$ means the integer part of the corresponding value.) Based on the formulation (12), we conclude that the optimal number of firms decreases with sunken cost and production costs, while increases with the market size.

The above optimal number of firms also suggests the importance to regulate the industry with collective quality. When many firms enter in this industry, it is extremely difficult to regulate (Basu & Dixit, 2017). By regulation to improve sunken costs, it is easy for this industry to monitor collective quality.

Under collective quality to deter entrants, the equilibrium may lock low quality. Therefore, it is important to upgrade quality to reach social optimal level. We further address the possible policies to transfer the collective quality from deterring entrant equilibrium to profit incentive equilibrium. Quality regulation and quality subsidies are considered to improve the collective quality.

For quality regulation, the simply restriction is to introduce the following lowest quality limitation $\kappa \geq \kappa^{*,3}$. Under this limitation, the optimal collective quality is exact the social optimal level. The corresponding properties are identical to those under social optimal level. In summary, the quality restriction seems easy and directive to transfer collective quality to social optimal degree.

We further address direct subsidy to transfer collective quality. One case is to subsidize the sunken costs. The other is to subsidize the marginal costs based on quality. The subsidized intensity is $\tau \geq 0$.

When the sunken costs are subsidized, the second stage is the same as that of [Section 4](#). The quality to deter entrants is rewritten as

$$\begin{aligned} \frac{(A-c_0)^2(1+\kappa)^2}{(N+1)^2} - F[1 + \kappa(1 - \tau)] &> 0, \\ \frac{(A-c_0)^2(1+\kappa)^2}{(N+2)^2} - F[1 + \kappa(1 - \tau)] &\leq 0. \end{aligned} \quad (13)$$

We then find that the collective quality $\kappa^{*,4} > \frac{F(N+1)^2}{(A-c_0)^2} - 1$. In general, the collective quality is higher than $\kappa^{*,1}$.

We then consider the subsidy to the marginal costs based on the quality. We also solve the model by the backward induction strategy. We then have

$$q_i = \frac{(A - c_0)(1 + \kappa) + \tau \kappa c_0}{N + 1}. \quad (14)$$

The corresponding profits are $\pi_i = \frac{[(A-c_0)(1+\kappa) + \tau \kappa c_0]^2}{(N+1)^2} - F(1 + \kappa)$. Similarly, we find that the collective quality $\kappa^{*,5}$ is also improved by the subsidy to marginal costs.

We find that the quality restriction seems more powerful than subsidies. Moreover, under asymmetric information, quality restriction seems more efficiency than others. This conclusion is consistent with the minimum quality standard proposed by Winfree and McCluskey (2005) and Winfree and McCluskey (2020). From another view, we conclude the similar result as Winfree and McCluskey (2005), and, Winfree and McCluskey (2020). Furthermore, quality restriction can achieve the social optimal collective quality. For different types of governmental interventions, the policy implication is to encourage quality restriction.

6. Concluding remarks

This article captures the relationship between competition and collective reputation. This article first argues that the collective quality depends on the firms' targets. Then the social optimal quality is achieved under profit incentive firms. We further argue that firms jointly determining quality improve both consumer surplus and producer surplus.

Finally, both the quality restriction and subsidy can improve the collective quality. Moreover, the quality restriction seems more efficient than subsidy.

In theory, this article first argues that collective quality jointly determined by profit incentive firms observes antitrust law or policies. Conclusions in this article are achieved for linear demands. When the demand is extended to general situations, conclusions also hold. The policy implications include two parts: One is that government should encourage to jointly determine collective quality for profit incentive firms. On the other hand, quality restriction seems more powerful than subsidy to achieve social optimal collective quality.

About the collective quality, some further researching topics arouse. On one hand, this article remarks collective quality under complete information. In general, under incomplete information, the quality is not known by opponents, and it is important to design mechanism to launch collective quality. On the other hand, the effects in short term are different from those in long term. Therefore, another issue is to address the collective quality in dynamic cases.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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