Quality regulation and competition in China's milk industry

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Abstract

Quality regulation is common in economic development. Based on the food safety problem, this paper employs game theory to capture the effects of milk power quality regulation of China on firm competition and industrial development. Firstly, quality regulation increases both variable costs and fixed costs of the regulated firms. High fixed costs hinder new entrants or force incumbents to quit the industry. Reputation increases quality as well as quantity and product substitution enhances the stimulating effects of reputation. Secondly, total quality under Cournot competition is higher than that under Stackelberg competition and reputation enlarges the quality gap between the two different competitions. Furthermore, reputation raises quality difference and price difference between firms under Stackelberg competition.

Keywords: Food safety. Government regulation. Reputation. Game theory.

1. Introduction

China Food and Drug Administration (CFDA) issued the infant formula milk powder production license examination rules on December 25, 2013, which was called the most stringent standard milk powder production license regulation. The new rules stipulate that all milk powder firms should adopt Good Manufacturing Practice (GMP), which is extensively

used in drug industry, and that milk firms should own their own meadow and use their own initial powder to produce milk powder. Following the rules, both variable and fixed costs of firms will arise. The purposes of the rules are to make sure that all links of infant formula milk power can be traced. People comment that the quality of milk powder will be improved but the negative impact of quality regulation is that half of milk powder production firms will quit or fail.

Since 1955, numerous milk safety incidents such as Arsenic in milk powder in Japan and baby milk scandal in China are listed in the list of major food contamination incidents. China is the largest developing country with the most people as well as children. The needs for milk by Chinese are increasing. As a result, many Chinese children only have inferior or even contaminated milk to drink. During the baby milk scandal of 2008, 300,000 babies are affected, with 51,900 hospitalizations and 6 infant deaths. In recent years, "tainted milk" scandals happened one after another in China. On the other hand, Chinese babies depend on milk more and more for that we are all nurtured by milk. This is why the Chinese government should carry out the most stringent standard milk powder production license rule.

Food safety is not only an ethical along with legal issue, but also an economic issue. Besides condemning and punishing the firms producing inferior products, we should analyze it by employing economic theory. So the propose of this paper is to illustrate why firms have no motivation to offer high quality products and how to stimulate them to produce superior goods, especially for food industries. This study indicates that the quality supplied by the firm depends on the reputation (or the quality-price elasticity parameter of the firm). Reputation is an exogenous variable and it can be impacted by firm behaviors such as advertising. Most of the time, the purpose of firms to invest in advertising is to improve their reputation. The relationship between reputation and food quality is an inverted U-shaped. In other words, low reputation lowers the food quality supplied but high reputation can also be bad for the firm because it decreases the demand seriously.

Based on the context of China milk quality regulation, this paper captures the relationships between the product quality and the reputation as well as competition by employing both Cournot and Stackelberg duopoly competitions. Firstly, quality regulation increases both variable costs and fixed costs of the regulated firms. High fixed costs hinder new entrants or force incumbents to quit the industry. Reputation increases quality as well as quantity and product substitution enhances the stimulating effects of reputation. Secondly, total quality under Cournot competition is higher than that under Stackelberg competition and

reputation enlarges the quality gap between the two kinds of competition. Furthermore, reputation raises quality difference and price difference between firms under Stackelberg competition.

2. Literature Review

Spence (1975) and Sheshinski (1976) initially addressed the quality and quantity competition by static game theory with monopoly model. Spence (1975) analyzed the relationships between regulation and return along with social welfare. Quality increases return as well as costs. Firm should make a tradeoff between price and quality. Spence (1975) also argued that rate-of-return regulation may attractive when quality is variable. Sheshinski (1976) had studied quality and quantity choices of monopolist. He focused his attention on the effects of various regulatory policies on the monopoly's decisions. In Sheshinski (1976)'s study, quality and quantity are chosen simultaneously. Another important early research or Dixit (1979)'s research also employed static model. Taking quality choice as non-price competition, Dixit (1979) considered several cases of oligopolistic equilibria, and compared them with each other and with the social optimum.

Static models have inherent shortages because they cannot capture the impact of quality on quantity. So many recent studies of quality competition use dynamic models (Mailath and Samuelson, 2001; Cheng and Peng, 2012; Board and Meyer-Ter-Vehn, 2013; Nie, 2014). Cheng and Peng (2012) showed that when the fixed setup cost of a product is high enough to lead to a monopoly outcome the monopolist always sells a single product, which means fixed cost plays a major role in quality competition. Board and Meyer-Ter-Vehn (2013) as well as Mailath and Samuelson (2001) addressed the effects of reputation on quality competition. Board and Meyer-Ter-Vehn (2013) fixed their study on equilibrium analysis under different conditions while Mailath and Samuelson (2001) issued that firms do not always benefit from high reputation if reputation is costly. Nie (2014) highlighted his study on capacity constraint and first mover advantage under quality and quantity. While Muege Parlaktürk and Swaminathan (2013) study the effects of resource constraints on multi-product quality competition.

Some authors incorporated other factors such costs (Chambers et al., 2006), differentiation and vertical integration (Matsubayashi, 2007), spatial competition (Brekke et al., 2010) and asymmetry (Matsubayashi and Yamada, 2008) to capture quality competition.

Chambers et al. (2006) highlighted the costs of duopoly in quality and price competition with a two-stage game model. Costs are significant in quality competition because they found that seemingly slight changes to the cost function's curvature can produce dramatically different equilibrium outcomes. Interestingly, Matsubayashi (2007) illustrated that under some mild conditions monopolistic vertical integration is beneficial for both the integrated firm and its consumers, while Brekke et al. (2010) employed a spatial competition framework to study the relationship between competition and quality. Matsubayashi and Yamada (2008) divided markets into two kinds called price-sensitive and quality-sensitive, and outlined the effect of consumer loyalty on quality competition. Besides, Nie and Chen (2014) studied food industry by considering food quality. More interestingly, other people considered demand-side strategies (Yi and Mukhopadhyay, 2013).

Quality competition as one of the major non-price competition has attracted a great deal of attention since the end of last century. Quality competition is quite complex for its multiple effects. On one hand, quality increases consumer utility and demand. On the other hand, quality raises price and decreases demand. Besides, quality innovation increases firms' variable as well as fixed costs. Prior studies have addressed quality competition under many different conditions. But another important factor, reputation involved by quality innovation should also be given more attention. So based on milk quality regulation of China, this paper highlights the effects of reputation and regulation on quality competition.

The rest of this paper is outlined as follows. The base model is set up in the next section. Then we analyze the base model under Cournot competition in section 4 and under Stackelberg competition in section 5, respectively. Section 6 compares the two alternative models. Conclusion and discussion is given in the last section.

3. Base Model

Although the demands for infant formula milk power are very large in China, the quality of milk power produced by domestic firms is quite low and numerous milk scandals happened in China recently. Based on those facts, the Chinese government implemented strict quality regulation at the end of year 2013. This paper assumes that quality regulation increases firm variable costs as well as fixed costs. There are two firms (or firm groups) denoted by $i \in \{1,2\}$ in the milk power industry. Both quantity and quality impact consumer utility. Given the quantities $q = (q_i, q_j)$ and qualities $x = (x_i, x_j)$ and combing Chen, Nie and

Wang (2015), Chen and Nie (2014) along with Nie (2014)'s studies, we employ the following utility function for the representative consumer

$$U(q_i, x_i) = (\alpha + \beta_i x_i)q_i + (\alpha + \beta_j x_j)q_j - \frac{1}{2}(q_i^2 + q_j^2) - \gamma q_i q_j. \quad (1)$$

Assume that $\beta_i = \beta_j = \beta$ represents the basic reputation parameter of firms resulting from quality investment and $\gamma \in [0,1]$ stands for the product substitutability. From function (1) we obtain the inverse demand function directly.

$$p_i = \alpha + \beta x_i - q_i - \gamma q_i. \quad (2)$$

Without loss of generality, this paper assumes the fixed costs of the duopoly are zero but increase to F_i, after quality regulation and firm costs with quality regulation are

$$C_i = \frac{1}{2}q_i^2 + \frac{1}{2}x_i^2 + q_i x_i + F_i. \quad (3)$$

The first and second terms of (3) represent the variable costs resulting from quantity investment and quality investment respectively, while the third term means the joint costs of quantity and quality. The last part of (3) illustrates the fixed costs. Then for the firm, we present the following profit maximization function.

$$\pi_i = (\alpha + \beta x_i - q_i - \gamma q_i)q_i - \frac{1}{2}q_i^2 - \frac{1}{2}x_i^2 - q_i x_i - F_i. \quad (4)$$

From function (4), we obtain the following proposition easily.

Proposition 1 If the fixed costs of quality innovation resulting from quality regulation are too high, firms will withdraw from or not enter the milk power industry.

Proof. The conclusion of Proposition 1 can be gotten by (4) directly. ■

Remarks: Proposition 1 is obvious and the policy implication of Proposition 1 is that the government should take the affordability of firms into consideration when they plan to implement quality regulation or the results will be counter to expectation. On one hand,

quality regulation improves products quality. On the other hand, quality regulation enhances monopoly despite it can eliminate inefficient firm. Unfortunately, the production efficiencies of domestic milk power firms are low now, so people forecast that nearly half of milk firms will be forced to quit. New regulation requires milk production firms to set up their own meadow and which makes the popular herder-firm model infeasible. Besides, all links of infant formula milk power can be traced after the new quality regulation. All those rules are fixed cost-sensitive. One feasible way to the government is to offer quality subsidy for the regulated firms.

Next, we will analyze the base model both under Cournot competition and Stackelberg competition by employing a three-stage game. In the first stage, the government issues the quality regulation plan and firms choose entry (exit) decision. In the second stage, firms make quality investment. And then in the final stage firms compete in quantity. All the solutions are gotten by backward induction method.

4. Cournot Competition

Different from Nie (2014), this paper only considers the case that both firms choose to stay in the industry in the first stage after the quality regulation. Given the quality regulation of the government, the two firms make quality decision in the second stage simultaneously and quantity decision in the third stage simultaneously. Under Cournot competition, we achieve the following solutions by solving function (4) with backward induction method.

$$(q_1^c, q_2^c) = \left(\frac{3(\alpha-\gamma)+3(\beta-1)x_1-(\beta-\gamma)x_2}{9-\gamma^2}, \frac{3(\alpha-\gamma)+3(\beta-1)x_2-(\beta-\gamma)x_1}{9-\gamma^2} \right). \quad (5)$$

Substituting (5) back into function (4) and re-solving it, we have the equilibrium quality of stage one.

$$(x_1^{c*}, x_2^{c*}) = \left(\frac{9\alpha(\beta-1)}{18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)}, \frac{9\alpha(\beta-1)}{18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)} \right). \quad (6)$$

Then we get the final equilibrium quantity of stage two

$$(q_1^{c*}, q_2^{c*}) = \left(\frac{\alpha(9-\gamma^2)}{18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)}, \frac{\alpha(9-\gamma^2)}{18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)} \right). \quad (7)$$

From (6) we acquire the following propositions.

Proposition 2 $1<\beta<\overline{\beta}$. That is, too low as well as too high β hinders quality investment.

Proof. $x_i^{c*} = \dfrac{9\alpha(\beta-1)}{18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)} \begin{cases} \le 0 & \beta \le 1 \\ > 0 & 1<\beta<\overline{\beta} \\ < 0 & \overline{\beta}<\beta \end{cases}$ which means firm implements quality only when $1<\beta<\overline{\beta}$.

Conclusions are therefore achieved and the proof is complete. ■

Remarks: Proposition 2 shows that there is an inverted U-shaped relationship between the reputation and quality innovation. Both high and low reputations are harmful to quality innovation. Firm does not invest quality investment if its reputation is too low or $\beta \le 1$ because the revenues of quality investment are less than the costs of quality investment. Taking the fact that the price of domestic milk power is much lower than that of imports into account, we draw the conclusion that the quality of domestic milk power is low because milk power production firms sell products with a low reputation. β is something like reputation, so milk power firm should invest in advertising to improve its reputation and we can also expect that milk production firms will make more advertising about its product quality after the quality regulation. High reputation (or $\overline{\beta}<\beta$) also hinders quality investment for that milk demand is β -sensitive, which means high β will decrease demand severely. The government should subsidize milk firms after quality regulation if they cannot enhance their reputation effectively or make carry out minimum price limit.

Proposition 3 $\dfrac{\partial x_i^{c*}}{\partial\beta}>0$, $\dfrac{\partial x_i^{c*}}{\partial\gamma}<0$ and $\dfrac{\partial^2 x_i^{c*}}{\partial\beta\partial\gamma}<0$.

Proof. Differentiating (6) by β and γ, we have $\dfrac{\partial x_i^{c*}}{\partial\beta} = \dfrac{9\alpha(36-18\beta+9\beta^2+9\gamma-3\gamma^2-\gamma^3)}{[18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)]^2} > 0$, $\dfrac{\partial x_i^{c*}}{\partial\beta} = -\dfrac{9\alpha(\beta-1)(9-6\gamma-3\gamma^2)}{[18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)]^2} < 0$ and $\dfrac{\partial^2 x_i^{c*}}{\partial\beta\partial\gamma} = -\dfrac{27\alpha(3-2\gamma-\gamma^2)[27(2-2\beta+\beta^2)+(9-3\gamma-\gamma^2)\gamma]}{[18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)]^3} < 0$ for $\beta\in(1,\overline{\beta})$, $\gamma\in[0,1]$ and all α ,directly.

Conclusions are therefore achieved and the proof is complete. ■

Remarks: Proposition 3 illustrates that reputation increases quality innovation, while substitutability decreases quality innovation which is the same as Nie and Chen (2014). More interestingly, substitutability reduces the effects of reputation on quality innovation. We can get similar conclusions from (7) for the same reasons for the quantity.

Importantly, the conclusions of Proposition 3 support Schumpeter (1942)'s opinion that monopoly increases innovation or contrary with Arrow (1962)'s. Furthermore, the government should encourage milk product firms to improve their reputation which can heighten the quality and help to relieve the food safety problem.

5. Stackelberg Competition

Notice that firms' statuses are not symmetric in reality most of the time, so in this section we will analyze the base model under Stackelberg competition. Assume that there are two firms (groups) in the market and without loss of generality this paper denotes firm $i=1$ the leader and $i=2$ the follower. Re-solving function (4) by backward induction method, we have the following optimal solutions of quality

$$\begin{aligned} x_1^{s*} &= \frac{\alpha(\beta-1)(9-3\gamma)[6-\gamma-2\gamma^2+(2\beta-\beta^2)(3+\gamma)]}{108-75\gamma^2+11\gamma^4+2\beta(108-30\gamma^2+\gamma^4)+\beta^2\gamma^2(18-\gamma^2)+(3\beta^4-12\beta^3)(9-\gamma^2)}, \\ x_2^{s*} &= \frac{\alpha(\beta-1)(9-\gamma^2)(6\beta+6-3\beta^2-3\gamma-\gamma^2)}{108-75\gamma^2+11\gamma^4+2\beta(108-30\gamma^2+\gamma^4)+\beta^2\gamma^2(18-\gamma^2)+(3\beta^4-12\beta^3)(9-\gamma^2)}. \end{aligned} \quad (8)$$

And the corresponding equilibrium quantities in the second stage are

$$\begin{aligned} q_1^{s*} &= \frac{\alpha(9-3\gamma)[6-\gamma-2\gamma^2+(2\beta-\beta^2)(3+\gamma)]}{108-75\gamma^2+11\gamma^4+2\beta(108-30\gamma^2+\gamma^4)+\beta^2\gamma^2(18-\gamma^2)+(3\beta^4-12\beta^3)(9-\gamma^2)}, \\ q_2^{s*} &= \frac{\alpha(9-2\gamma^2)(6\beta+6-3\beta^2-3\gamma-\gamma^2)}{108-75\gamma^2+11\gamma^4+2\beta(108-30\gamma^2+\gamma^4)+\beta^2\gamma^2(18-\gamma^2)+(3\beta^4-12\beta^3)(9-\gamma^2)}. \end{aligned} \quad (9)$$

From (8) and (9), we have the following propositions.

Proposition 4 The conclusions of Proposition 2 and Proposition 3 still hold under Stackelberg competition. But the upper bound of reputation here is smaller than that under Cournot competition.

Proof. From (8), we have $\begin{cases} x_i^{s*} \le 0, & \beta \le 1 \\ x_i^{s*} > 0, & 1 < \beta < \overline{\overline{\beta}} \\ x_i^{s*} < 0, & \beta > \overline{\overline{\beta}} \end{cases}$, $\frac{\partial x_i^{s*}}{\partial \beta} > 0$, $\frac{\partial x_i^{s*}}{\partial \gamma} < 0$ and $\frac{\partial^2 x_i^{s*}}{\partial \beta \partial \gamma} < 0$, directly. Besides, we have $2.3 < \overline{\overline{\beta}} < 2.4$, so $\overline{\overline{\beta}} < \overline{\beta}$. The season for that the upper bound of β should not too high is the same as footnote 9.

Conclusions are therefore achieved and the proof is complete. ■

Remarks: On one hand, Proposition 4 indicates that the conclusions of Proposition 2 and Proposition 3 are robust. On the other hand, Proposition 4 shows that Stackelberg competition has severer limit on the reputation.

Denote the difference in quality under Stackelberg competition as $\Delta x = x_1^{s*} - x_2^{s*}$.

Then we get the following proposition.

Proposition 5 $\Delta x > 0$, $\frac{\partial \Delta x}{\partial \beta} > 0$ and $\frac{\partial \Delta x}{\partial \gamma} > 0$.

Proof. From (8), we have

$$\Delta x = \frac{\alpha(\beta-1)(3-\gamma)\gamma^3}{108-75\gamma^2+11\gamma^4+2\beta(108-30\gamma^2+\gamma^4)+\beta^2\gamma^2(18-\gamma^2)-3\beta^3(9-\gamma^2)(4-\beta)} > 0$$ for all α, $\gamma \in [0,1]$ and $\beta \in (1, \overline{\overline{\beta}})$. Then we get $\frac{\partial \Delta x}{\partial \beta} > 0$ and $\frac{\partial \Delta x}{\partial \gamma} > 0$ by the expression of Δx, directly.

Conclusions are therefore achieved and the proof is complete. ■

Remarks: The two firms offer the same quality under Cournot, while the leading firm supplies high quality than the follower under Stackelberg. Proposition 4 shows the reputation increases firms' quality and substitutability decreases it. But Proposition 5 illustrates that both the reputation and substitutability enlarge the difference of the two firms, which means the reputation increases the quality of the advantage firm more while the inhibiting effects of substitutability on the disadvantage firm are critical than on the advantage one. The results also show that the reputation increases the price difference under Stackelberg competition despite firms' reputation are the same.

6. Comparative analysis

The purposes for the government to implement quality regulation are to heighten total quality, consumer utility along with social welfare. So we will compare those factors between different competitions.

Denote the total quality of the two firms under Cournot and Stackelberg competition as Σx^{c*} and Σx^{s*}. CS^c and CS^s represent the consumer surplus of Cournot competition and Stackelberg competition , respectively. Then we have

Proposition 6 $\Sigma x^{c*} > \Sigma x^{s*}$ and $CS^c < CS^s$.

Proof. Combining (6) and (8), this study gets

$$\Sigma x^{c*} - \Sigma x^{s*} = \frac{1}{18(\beta+1)-9\beta^2+\gamma(9-3\gamma-\gamma^2)} \times \frac{\alpha(\beta-1)[54-45\gamma-12\gamma^2+12\gamma^3+\gamma^4+(6\beta-3\beta^2)(9-3\gamma^2-2\gamma^2)]}{[108-75\gamma^2+11\gamma^4+2\beta(108-30\gamma^2+\gamma^4)+\beta^2\gamma^2(18-\gamma^2)-3\beta^3(9-\gamma^2)(4-\beta)]} > 0.$$

Combining $CS = U(x_i, q_i) - \sum_{i=1}^{2} \Sigma p_i q_i$ with (1) and (2), we have $CS = \frac{1}{2}(q_1^2 + q_2^2) + \gamma q_1 q_2$.

From functions (7) and (9), we obtains $CS^c - CS^s < 0$, or $CS^c < CS^s$ easily.

Conclusions are therefore achieved and the proof is complete. ■

Remarks: The conclusions of Proposition 6 are quite interesting. Although total quality is higher under Cournot competition than that under Stackelberg competition, the relationship of consumer surplus between the two different cases is overturn, which means high quality cannot increase consumer surplus despite that quality does improve consumer utility. The reason is that consumer should pay for any quality increase. Besides, the expression of CS also shows that consumer surplus has nothing to do with quality.

Denote producer surplus by PS and social welfare $SW = CS + PS$. The corresponding social welfare under Cournot competition and Stackelberg competition are SW^{c*} and SW^{s*}. Besides, this paper assumes the fixed costs of the identical firms are the same. Then for the social welfare, we have the following proposition.

Proposition 7 there is a $\hat{\beta}$ such that the relationship of social welfare under different competition satisfies $\begin{cases} SW^{c*} > SW^{s*}, & 1 < \beta < \hat{\beta} \\ SW^{c*} < SW^{s*}, & \hat{\beta} < \beta < \overline{\beta} \end{cases}$.

Proof. $SW^{c*} = CS^{c*} + PS^{c*} = 2p^{c*}q^{c*} - \left(x^{c*}\right)^2 - 2x^{c*}q^{c*} + \gamma\left(q^{c*}\right)^2 - F_1 - F_2$ for that $(x_1^{c*}, q_1^{c*}, p_1^{c*}) = (x_2^{c*}, q_2^{c*}, p_2^{c*})$ and $SW^{s*} = \sum_{i=1}^{2}\left(p_i^{s*}q_i^{s*} - \frac{1}{2}x_i^{s*} - x_i^{s*}q_i^{s*} - F_i \right) + \gamma q_1^{s*}q_2^{s*}$.

Substituting the equilibrium price, quality as well as quantity under different competition to $SW^{c*} - SW^{s*}$, we obtain the conclusions of Proposition 7.

Conclusions are therefore achieved and the proof is complete. ■

Remarks: As Proposition 6 shows that consumer surplus is higher under Stackelberg competition than under Cournot condition, but the relationship of total social welfare between the two competition modes is ambiguous. The policy implication of Proposition 6 is that if firms play the Cournot game, the government should implement some regulation (or limit), while if they paly the Stackelberg game, then the government should encourage firms to improve their reputation, because the increase in reputation enhances the total social welfare.

8. Conclusion and Discussion

People all know that market failure exists under some conditions. So letting the market develop without any supervision may result in severely bad consequence, particularly in some special industries such as food and drug industry. Based on those reasons, we need government regulations. But government regulation also causes cost or even leads to negative result, too.

Food accident is a serious problem in China. So based on the milk power quality regulation, this paper captures the impacts of quality regulation to milk power production firms' competition and highlights the effects of reputation on quality competition, consumer surplus as well as social welfare both under Cournot competition and Stackelberg competition. Quality regulation increases milk power production firms' variable costs along with fixed costs and if firms' fixed costs increase too much after quality regulation, the government should provide them with subsidies.

More importantly, this paper shows that reputation has significant influences on quality competition. Both too high and too low reputations are harmful to quality innovation or there is an effective range for reputation. The government should carry out different policies along milk power quality regulation under different conditions. Why the quality

produced by domestic firms is much lower than foreign enterprises? A reasonable explanation is that the reputation based on quality innovation is quite low for them.

This paper assumes the same reputation for firms. But different firms may have different abilities in reality, so we will capture the effects of different reputation in the next study.

9. References

ARROW, K. Economic welfare and the allocation of resources for inventions, In The Rate and Direction of Inventive Activity, ed. R. Nelson, Princeton, N.J., *Princeton University Press*, 1962.

BREKKE, K. R.; SICILIANI, L.; SICILIANI, O. P. Price and quality in spatial competition, *Regional Science and Urban Economics*, Vol. 40, n. 6, p. 471-480, 2010.

BOARD, S.; MEYER-TER-VEHN, M. Reputation for quality, *Econometrica*, Vol. 81, n. 6, p. 2381-2462, 2013.

CHAMBERS, C.; CHAMBERS, P.; SEMPLE, J. Quality-Based Competition, Profitability, and Variable Costs, *Management Science*, Vol. 52, n. 12, p. 1884-1895, 2006.

CHENG, Y. L.; PENG, S. K. Quality and quantity competition in a multiproduct duopoly. *Southern Economic Journal*, Vol. 79, n. 1, p. 180-202, 2012.

CHEN, Y. H.; NIE, P. Y. Duopoly innovation under product externalities, *Economic Research-Ekonomska Istraživanja*, Vol. 27, n. 1, p. 232-243, 2014.

CHEN, Y. H.; NIE, P. Y.; WANG, X. H. Asymmetric duopoly competition with innovations spillover and input constraints, *Journal of Business Economics and Management*, to appear, 2015.

DIXIT, A. Quality and quantity competition, *Review of Economic Studies*, Vol. 46, n. 4, p. 587-599, 1979.

MAILATH, G. J.; SAMUELSON, L. Who wants a good reputation? *Review of Economic Studies*, Vol. 68, n. 2, p. 415-441, 2001.

MATSUBAYASHI, N. Price and quality competition: The effect of differentiation and vertical integration, *European Journal of Operational Research*, Vol. 180, n. 2, p. 907–921, 2007

MATSUBAYASHI, N.; YAMADA, Y. A note on price and quality competition between asymmetric firms, *European Journal of Operational Research*, Vol. 187, n. 2, p. 571-581, 2008

MUEGE, Y-K. H.; PARLAKTÜRK, A. K.; SWAMINATHAN, J. M. Multi-Product Quality Competition: Impact of Resource Constraints, *Production and Operations Management*, Vol. 22, n. 3, p. 603-614, 2013.

NIE, P. Y. Quantity and quality competition considering capacity constraints and first move advantages, *Working paper*, 2014.

NIE, P. Y.; CHEN, Y. H. A general equilibrium analysis of food industry considering the food quality, *Agricultural Economics*, Vol. 60, n. 7, p. 301-308, 2014.

SCHUMPETER, J. A. Capitalism, Socialism and Democracy, New York, Harper, 1942.

SHESHINSKI, E. Quality and quantity regulation in monopoly situation, *Economica*, Vol. 43, n. 170, p. 127-137, 1976.

SPENCE, A. M. Monopoly, quality and regulation, *Bell Journal of Economics*, Vol. 6, n. 2, p. 417-429, 1975.

YI, G.; MUKHOPADHYAY, S. K. Role of demand-side strategy in quality competition, *International Journal of Production Economics*, Vol. 145, n. 2, p. 696-701, 2013.

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