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PARTIAL VS. FULL DELEGATION WITHIN A SPATIAL GAME

Several trends of industrial organization are emphasized in this paper: strategic delegation, R&D spillovers and product differentiation. The authors distinguish between two kinds of delegation: partial and full delegation, in the context of both spillovers and product differentiation endogenously determined by firms. By studying the delegation impact on location, R&D investment and price decisions, it is demonstrated that: 1) partial delegation encourages one firm to locate farther from the rival, while full delegation induces owners to choose a closer location pattern; 2) partial delegation stimulates firms' own spending on R&D and fosters firms to produce higher quality goods as compared to full delegation; 3) partial delegation renders managers less aggressive and let managers fix a higher price than full delegation.

Keywords: *endogenous spillovers; full delegation; partial delegation; horizontal differentiation.*
JEL classification: *O31; L13; L20; D43.*

Као Жао

ЧАСТКОВЕ ТА ПОВНЕ ДЕЛЕГУВАННЯ У ПРОСТОРОВОМУ МОДЕЛЮВАННІ ПРОЦЕСІВ УПРАВЛІННЯ

У статті досліджено взаємодію трьох явищ: стратегічного делегування, обміну науково-дослідними розробками та продуктової диференціації. Порівняно вплив двох типів делегування – часткового та повного – на науково-дослідницькі розробки фірм та їх політику продуктового різноманіття. Доведено, що: 1) при частковому делегуванні фірми намагаються розташуватися на ринку подалі від конкурентів, у той час як при повному делегуванні фірми тримаються поблизу від конкурентів; 2) часткове делегування більше, ніж повне, стимулює витрати на наукові розробки та підвищення якості продукту; 3) при частковому делегуванні політика менеджерів менш агресивна, а ціни – вище, ніж при повному делегуванні.

Ключові слова: *однорідний обмін запозиченнями; повне делегування; часткове делегування; горизонтальна диференціація.*
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Као Жао

ЧАСТИЧНОЕ И ПОЛНОЕ ДЕЛЕГИРОВАНИЕ В ПРОСТРАНСТВЕННОМ МОДЕЛИРОВАНИИ ПРОЦЕССОВ УПРАВЛЕНИЯ

В статье исследовано взаимодействие трёх явлений: стратегического делегирования, обмена научно-исследовательскими разработками и продуктовой дифференциации. Сравнено влияние двух типов делегирования – частичного и полного – на научно-исследовательские разработки фирм и их политику продуктового разнообразия. Доказано, что: 1) при частичном делегировании фирмы стараются разместиться на рынке как можно дальше от конкурентов, в то время как при полном делегировании фирмы держатся вблизи конкурентов; 2) частичное делегирование больше, чем полное делегирование, стимулирует расходы на научные разработки и повышение качества продукта; 3) при частичном делегировании политика менеджеров менее агрессивна, а цены – выше, чем при полном делегировании.

Ключевые слова: *однородный обмен заимствованиями; полное делегирование; частичное делегирование; горизонтальная дифференциация.*

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1. Introduction

Conventional wisdom suggests that internal organization has profound effects on firm's productivity, efficiency and growth. Many contributions have exploited the field of the relationship between organizational design and its effects on firms' performance. Over the past two decades, there has been a growing interest in the link between delegation and R&D activities. However, the choice of different types of delegation in this context has received little attention. What kind of delegation is more conducive to technological advancement and firm's growth? How does the downstream product competition influence the managerial contracts and the incentive for upstream R&D? How do owners choose different types of managerial incentives and how does this affect market outcomes? Whether the delegation strategy can improve the consumer surplus and social welfare, and which one serves best? This paper attempts to address these questions by studying the location – R&D – price framework.

Delegation introduced by Schelling (1960) has received great attention in the industrial organization literature. Earlier theoretical work on delegation has shown that firms have a unilateral incentive to delegate tasks to independent agents. Vickers (1985), Fershtman and Judd (1987), Sklivas (1987), Fershtman, Judd and Kalai (1991) show that in a two-stage Cournot quantity game, owners have incentives to delegate short-run decisions to their managers, and in equilibrium there are higher outputs than in the classic Cournot game. This early work, nevertheless neglects the fact that there is another category of decisions which should be taken into consideration, regarding the long-term plans of the firm, such as R&D. Zhang and Zhang (1997) were the first to introduce the model which combines strategic delegation with R&D in the presence of spillovers. They consider a three-stage game, where owners delegate decisions on R&D investments and production quantities to managers. Barcena-Ruiz and Olaizola (2006), Mitrokostas and Petrakis (2005) demonstrate in a similar setup under which circumstances it is optimal to delegate either only short-run (output) decisions, or R&D investments as well to managers. Unlike Zhang and Zhang (1997), they exclude spillover effects and apply a different characterization of the R&D investment. Little work has yet been done to analyze the effects in a differentiated price competition setting with delegation, particularly when spillover effects on product qualities (or costs) are explicitly modelled.

The notion of spillovers has been formalized by d'Aspremont and Jacquemin (1988) as well as by Kamien, Muller and Zang (1992) in the context of oligopolistic competition. Spillovers are considered as "manna from heaven" (Kamien, Zang, 2000). They assume that a fixed and exogenously given portion of every firm's process R&D effort leaks and contributes to cost reduction or quality enhancement for other firms. Recently the study of spillovers is divided into two main avenues: "impact spillovers" and "endogenous spillovers". The former highlights that spillovers are affected by different kinds of factors, such as absorptive capacity (Cohen, Levinthal, 1990), ex-ante adaptability and ex post information sharing (Katsoulacos, Ulph, 1998). The latter emphasizes that there is a closer relationship between product differentiation and spillovers, particularly in a spatial game (Piga, Poyago-Theotoky, 2005 (hereafter PPT); Dey, Fu, 2009). Our framework chooses the "endogenous spillover" avenue in order to gain some insights into the interdependence of ownership structure, firm's location pattern, product variety, product quality and market competition.

Concerning managerial contracts, we adopt the incentive contracts which consist of a combination of profits and market share. Much anecdotal evidence about the importance of market share motives emerged in business press and management literature. A classic example is Jack Welch's "General Electric", which publicly announced that its key objective is to be #1 at all the markets in which it operates (Welch, 2003). Another example relates to media industries, where market share in terms of listeners (radio stations), readers (newspaper dailies) and viewers (TV channels) is the key to success. Moreover, from the empirical viewpoint, Peck (1988) mentions that market share is highly ranked in managers' objectives. All these arguments induce us to explore delegation game with market share contracts.

The contribution of this paper is three-fold. First, we extend the strategic delegation game by introducing endogenous spillovers. This enables a study on how delegation structure affects firms' location, R&D as well as their price decisions in the context of both spillovers and product differentiation endogenously determined. The second contribution is that we distinguish between two kinds of delegation: partial delegation, in which firms' owners delegate only short-run decisions to their managers; full delegation, in which owners delegate both short-run and long-run decisions. The third contribution is to draw on two major types of product differentiation.

Both empirical evidence and various examples can be used to illustrate partial and full delegations. It is shown that owners tend to delegate only short-run decisions to their managers, while they prefer to preserve control over long-run decisions, in some companies. For instance, the owners of BMW are very much involved in firm management (in its long-run decisions), at the same time they delegate short-run decisions such as marketing plans to the managers of subsidiaries. Additional evidence is given by "Microsoft", where Bill Gates plays a dominant role in long-term strategic decisions of the firm. By contrast, in some firms top managers take both long-run and short-run decisions. This is the case of "Kraft", one of America's best-known brand names in food products (Boyd, 1990).

This paper not only explores the issue of whether owners choose strategic commitment to achieve gains from delegation, but also answers to question what type of delegation they prefer to adopt. We analyze the incentive contracts that owners choose for their managers focusing on how owners may strategically manipulate such contracts and their effect on the degree of product differentiation and the level of spillovers. Furthermore, the analysis of consumer surplus and social welfare is taken into account. By this work, we are able to investigate whether delegation policies benefit consumers and give rise to a higher level of social welfare.

The reminder of the paper is organized as follows. Section 2 describes the model and Section 3 explores the equilibrium in 3 alternative scenarios. In Section 4, we derive our main results. Then, Section 5 presents the analysis in terms of welfare. Some brief concluding remarks are offered in Section 6.

2. The model

Consider a linear city along the unit interval $[0;1]$, where consumers are uniformly distributed along the interval. Firm i is allowed to locate at $y_i'' [0,1]$ and cannot change their locations in the future. Marginal costs of production c are assumed

to be constant and identical for both firms. In what follows, we set $c = 0$ to simplify the analysis. Firms undertake R&D efforts in order to improve the quality of their product, and the R&D investment engaged by one firm may benefit the other firm at no cost via spillover effect. As a result of the spillover, a non-negative portion $\lambda''[0, 1]$ of the rival firm j' R&D input contributes to firm i's effective R&D. Firm i's effective R&D effort X_i can be represented as a function of both firms' R&D efforts $X_i = x_i + \lambda x_j$. The parameter λ is the spillover measure indicating the level of leakage or appropriability, which is related to firms' locations (product configurations or characteristics). It is assumed that the greater is the distance between two firms, the more differentiated are the firms' products, the less are the R&D spillovers. Define $\lambda = 1 - y_j + y_i$ which is at the maximum when firms share the same location ($y_i = y_j$) and will be the minimum value when firms are located at market endpoints ($y_i = 0$; $y_j = 1$). In addition, there are diminishing returns to quality-improving R&D, the costs of R&D are given by $(\gamma x_i^2)/2$, where γ is the measure of R&D effectiveness[2].

Assume each firm has a principal (i.e. owner, board of directors, shareholder) and an agent (i.e. manager, CEO). Principals wish to maximize profits but delegate decision-making to agents, who receive strategic incentive contracts and maximize their compensation. Concretely, owner i wants to maximize firm's profit $\pi_i = p_i D_i - (\gamma/2)x_i^2$ and has the option to hire a manager to make short-run price and/or long-run R&D investment decisions.

The manager's objective function at the product market places weight on both profits and market share $U_i = \pi_i + \theta_i(D_i/(D_i + D_j))$, where the weight θ_i is a number chosen by owner i in order to maximize profit. Notice that there is no constraint for θ_i. Compensation contracts are publicly observable and have the form $A_i + B_i U_i$, where A_i represents his fixed salary, $B_i U_i$ equals a performance-related bonus with $B_i > 0$. Since manager i is risk-neutral, he acts to maximize U_i and the values of A_i and B_i are irrelevant. It is worth while to note that D_i is not only the quantity supplied by firm i but also the market share of firm i because the total demand $(D_i + D_j)$ is normalized to 1. Therefore, the manager's objective function can be rewritten as $U_i = \pi_i + \theta_i D_i$.

The timing of the game is as follows:

I. Owners choose the location simultaneously.

II. Owners either decide on R&D effort or delegate this decision to managers, in which case owners choose a contractual parameter θ_i; delegation at this stage also implies delegation of price decisions at the next stage.

III. Owners can decide to delegate price decision or retain it for themselves.

IV. Decision-makers (owners or managers) simultaneously decide on a price.

Notice that contracts cannot be renegotiated and they become common knowledge once they are signed. Overall, owners have 3 alternative strategies: no delegation, partial delegation and full delegation. The first is that in which no decision is delegated to managers; the second refers to the case in which owners delegate only short-run price decisions to their managers; and the third one is related to the case where owners delegate both short-run price and long-run R&D investment decisions.

[2] As γ increases, the expenditure required for a firm to obtain a given quality increases.

As shown in PPT (2005), suppose a consumer located at $s'' [0,1]$, who decides to buy one unit from firm i, receives a utility $v + X_i - p_i - t(s - y_i)^2$, if this consumer purchases the product from the firm located at a point y_i and pays a price p_i. Note that $t'' (\underline{t}, \bar{t})$ refers to an index[3] of the transportation cost per unit, it indicates the degree of consumer heterogeneity. The basic reservation utility $v > 0$ is sufficiently large so that market is fully covered. The effective R&D X_i is transformed into consumer's value so that $v + X_i$ is the highest price a consumer would pay for the product, on the other hand, X_i can be in effect interpreted as quality enhancement which differs the products vertically. This vertical differentiation is endogenously determined by firm's locations chosen by owners and R&D efforts chosen by either owners or managers. Furthermore, the firm's locations also represent the characteristics of products. The distance between the two firms determines the extent of spillover. Thereby, the positions of firms not only horizontally reflect product's characteristics and vertically affect the product's quality, but also mirror the degree of spillovers.

3. Equilibrium and analysis

In this section, we solve for the equilibrium of the multi-stage game by backward induction. We first define the demands for the two firms. The surplus from purchasing a unit from firm i to a consumer located at s, is $v - p_i - t(s - y_i)^2 + X_i$, and the surplus for buying from firm j is $v - p_j - t(s - y_j)^2 + X_j$. By determining the consumer who is indifferent between the two firms, we can derive the respective demands addressed to firm i and firm j.

$$D_i = s = \frac{(p_j - p_i) - (X_j - X_i)}{2t(y_j - y_i)} + \frac{y_j + y_i}{2}, \quad D_j = 1 - s = 1 - \frac{(p_j - p_i) - (X_j - X_i)}{2t(y_j - y_i)} - \frac{y_j + y_i}{2}$$

3.1. No delegation (benchmark case)

Price stage

The profit functions for firm i and firm j are given by

$$\pi_i = p_i D_i - \tfrac{\gamma}{2} x_i^2, \quad \pi_j = p_j D_j - \tfrac{\gamma}{2} x_j^2 \tag{1}$$

Owners simultaneously and independently decide the price to maximize their profits. From the first order conditions (henceforth "FOC") we obtain the equilibrium prices:

$$p_i = \frac{1}{3}\left[X_i - X_j + t(y_j - y_i)(2 + y_i + y_j)\right], \quad p_j = \frac{1}{3}\left[X_j - X_i + t(y_j - y_i)(4 - y_i - y_j)\right] \tag{2}$$

R&D (quality) stage

We now explore firms' equilibrium R&D decisions at this stage, with a given location profile (y_i, y_j). After taking FOCs we obtain the equilibrium R&D efforts.

$$\begin{aligned} x_i &= \frac{(y_j - y_i)\left[3t\gamma(2 + y_i + y_j) - 2(y_j - y_i)\right]}{3\gamma\left[9t\gamma - 2(y_j - y_i)\right]}, \\ x_j &= \frac{(y_j - y_i)\left[3t\gamma(4 - y_i - y_j) - 2(y_j - y_i)\right]}{3\gamma\left[9t\gamma - 2(y_j - y_i)\right]} \end{aligned} \tag{3}$$

Location stage

We obtain the following equilibrium:

$\underline{t} = \frac{5}{18\gamma}$ and $\bar{t} = \frac{2(9+\gamma\sqrt{21})}{75\gamma}$

$$y_i = \frac{4 - 12t\gamma - 27t^2\gamma^2 + 9t\gamma\sqrt{3t\gamma(2+3t\gamma)}}{4(2+3t\gamma)}, \qquad y_j = \frac{4 + 24t\gamma + 27t^2\gamma^2 - 9t\gamma\sqrt{3t\gamma(2+3t\gamma)}}{4(2+3t\gamma)} \tag{4}$$

By making use of (4), we can compute the equilibrium levels for all the other relevant variables. These values are shown in Table 1.

Table 1. **Equilibrium values under no delegation**

Equilibrium values	No delegation (superscript "N")
R&D investment	$x_i^N = x_j^N = \frac{3t\left[2+3t\gamma-\sqrt{3t\gamma(2+3t\gamma)}\right]}{2(2+3t\gamma)}$
Quality	$X_i^N = X_j^N = \frac{3t^2\gamma\left[8+9t\gamma\sqrt{3t\gamma(2+3t\gamma)}-3t\gamma(2+9t\gamma)\right]}{2t\gamma(2+3t\gamma)\left[2+3t\gamma+\sqrt{3t\gamma(2+3t\gamma)}\right]}$
Price	$p_i^N = p_j^N = \frac{9t^2\gamma\left[2+3t\gamma-\sqrt{3t\gamma(2+3t\gamma)}\right]}{2(2+3t\gamma)}$
Profit	$\pi_i^N = \pi_j^N = \frac{9t^2\gamma}{4(2+3t\gamma)}$

Source: Authors.

3.2. Partial delegation

Price decisions are delegated to managers, while owners decide themselves the quality-improving R&D investments. Thus, after the locational decisions are made, owners decide on their R&D efforts, and then set the incentive schemes for their managers. Finally, managers compete by setting the prices. The equilibrium R&D efforts, managerial contracts, prices, qualities and profits are shown in Table 2.

Table 2. **Equilibrium values under partial delegation**

Equilibrium values	Partial delegation (superscript "P")
Location	$y_i^P = \frac{16 - 5t\gamma\left[16 + 25t\gamma - 5\sqrt{5t\gamma(4+5t\gamma)}\right]}{8(4+5t\gamma)}$ and $y_j^P = \frac{16 + 5t\gamma\left[24 + 25t\gamma - 5\sqrt{5t\gamma(4+5t\gamma)}\right]}{8(4+5t\gamma)}$
R&D investment	$x_i^P = x_j^P = \frac{5t\gamma\left[4+5t\gamma-\sqrt{5t\gamma(4+5t\gamma)}\right]}{2\gamma(4+5t\gamma)}$
Quality	$X_i^P = X_j^P = \frac{5\left[t\gamma(25t\gamma-4)\sqrt{5t\gamma(4+5t\gamma)}+16t\gamma-5t^2\gamma^2(6+25t\gamma)\right]}{4\gamma(4+5t\gamma)}$
Contract	$\theta_i^P = \theta_j^P = \frac{25t^2\gamma\left[\sqrt{5t\gamma(4+5t\gamma)}-(4+5t\gamma)\right]}{4(4+5t\gamma)}$
Price	$p_i^P = p_j^P = \frac{25t^2\gamma\left[(4+5t\gamma)-\sqrt{5t\gamma(4+5t\gamma)}\right]}{2(4+5t\gamma)}$
Profit	$\pi_i^P = \pi_j^P = \frac{25t^2\gamma}{2(4+5t\gamma)}$

Source: Authors.

3.3. Full delegation

In this scenario, owners delegate both long-run R&D decisions and short-run price decisions to managers. Accordingly, owners first of all choose firms' positions, and then decide the incentive schemes to maximize profits. Managers take charge of R&D and price decisions on owner's behalf. The equilibrium levels for all the other relevant variables are shown in Table 3.

Table 3. **Equilibrium values under full delegation**

Equilibrium values	Full delegation (superscript "F")
Location	$y_i^F = \frac{140 - 9t\gamma\left[29 + 18t\gamma - \sqrt{121 + 36t\gamma(14 + 9t\gamma)}\right]}{20(14 + 9t\gamma)}$ and $y_j^F = \frac{140 + 9t\gamma\left[49 + 18t\gamma - \sqrt{121 + 36t\gamma(14 + 9t\gamma)}\right]}{20(14 + 9t\gamma)}$
R&D investment	$x_i^F = x_j^F = \frac{3t\gamma\left[3(13 + 6t\gamma) - \sqrt{121 + 36t\gamma(14 + 9t\gamma)}\right]}{20\gamma(14 + 9t\gamma)}$
Quality	$X_i^F = X_j^F = \frac{3t\gamma\left[\sqrt{121 + 36t\gamma(14 + 9t\gamma)}(162t^2\gamma^2 + 261t\gamma - 140) - 2916t^3\gamma^3 - 6966t^2\gamma^2 - 1359t\gamma + 546\right.}{50\gamma(9t\gamma + 14)^2}$
Contract	$\theta_i^F = \theta_j^F = \frac{9t^2\gamma\left[\sqrt{121 + 36t\gamma(14 + 9t\gamma)} - 3(13 + 6t\gamma)\right]\left[2\sqrt{121 + 36t\gamma(14 + 9t\gamma)} - (8 - 9t\gamma)\right]}{50(14 + 9t\gamma)^2}$
Price	$p_i^F = p_j^F = \frac{9\left[18t^2\gamma^2 - t\gamma\sqrt{121 + 36t\gamma(14 + 9t\gamma)} + 39t\gamma\right]\left[27t^2\gamma^2 + t\gamma\sqrt{121 + 36t\gamma(14 + 9t\gamma)} + 31t\gamma\right]}{25\gamma(9t\gamma + 14)^2}$
Profit	$\pi_i^F = \pi_j^F = \frac{9t^2\gamma\left[11\sqrt{121 + 36t\gamma(14 + 9t\gamma)} + 271 + 252t\gamma\right]}{20(14 + 9t\gamma)^2}$

Source: Authors.

4. Results

By using the outcomes established in the previous section, we compare 3 alternative delegation strategies in terms of firm's location, R&D spillovers, product quality, market price and profit.

4.1. Firm's location

Each owner chooses the firm's location before conducting R&D activity and marketing products decided personally, or by a manager. The impact of location configuration decision is twofold: on the one hand, it determines the extent of product (horizontal) differentiation; on the other hand, location choice affects the ability of the firm to obtain beneficial R&D spillovers. Specifically, distinctly differentiated products restrict R&D spillovers, while more homogeneous products allow firms take advantage of more information flows.

Result 1. $0 \le y_i^p < y_i^N < y_i^F < \frac{1}{2} < y_j^F < y_j^N < y_j^p \le 1$

The firms' equilibrium location pattern balances the trade-off they face between the benefit from softened price competition by furthering product differentiation and the benefit from softened R&D competition by reducing differentiation. We find that the distance between firms in full delegation case is closer than the one in no delegation case. As the benefits from the rival's R&D effort prevail over the gains from weakening price competition, within full delegation, therefore, owners always have more incentive to position their products closer to each other.

We also find that partial delegation strategy encourages one firm to locate farther from the rival. In particular, firms could locate at the two respective extremities of market that generates the minimal spillover effect when transportation rate is equal to the upper bound. It is worth noting this phenomenon corresponds to the remark of Kamien and Zang (2000) who state that firms choose firm-specific R&D approaches to offset exogenous spillovers. In addition, it is clear that firms never share the same place which gives rise to maximal spillovers.

As the extent of spillovers depends on firms' locations, more precisely, the distance between competing firms, it is straightforward to derive:

Result 2. $1 > \lambda^F > \lambda^N > \lambda^P \geq 0$ and $0 > \frac{\partial \lambda^N}{\partial t} > \frac{\partial \lambda^F}{\partial t} > \frac{\partial \lambda^P}{\partial t}$

The extent of spillover is the decreasing function of transportation cost. Therefore, geographical and researchful isolation is preferred when firms are protected by higher transport costs. Firms want to locate as far as possible from each other to relax price competition. On the other hand, locational proximity benefits firms, because they can learn more from each other's quality-enhancing R&D. It is the interplay between these two forces that influences the spillover effect: the centrifugal force that leads firms to locate apart and the centripetal force that induces them to locate at a proximity to benefit from spillovers. The lower is the transportation cost, the closer to each other firms locate and the more they benefit from each other's R&D. It is clear that traditional centrifugal force that would make firms locate as far away as possible from each other is partly offset by the centripetal force that induces them to locate closer.

In equilibrium, compared to the benchmark case, full delegation strategy generates higher R&D spillovers, whereas, partial delegation strategy leads to lower spillovers. When owners delegate short-term price decisions, the spillover rate function is the most sensitive, firms have the most incentives to locate separately following an augmentation of transport cost. In full delegation, owners have less incentives to position firms far away compared to partial delegation, because gains from the closer location pattern within full delegation are greater than that within partial delegation, this effect reduces the tendency to separate.

4.2. Research and development effort

Result 3. $x^P > x^N > x^F > 0$

Partial delegation strengthens firms' incentives for product differentiation and propels firms to further segregate the market. On the contrary, full delegation encourages firms to position closely in order to reduce product heterogeneity and to reinforce R&D sharing. Thus, delegation influences the choice of firm's location, in turn, affects R&D spillovers, and will indirectly (no and partial delegation) or directly (full delegation) effect on R&D investment. Partial delegation has firms located further away from each other, thereupon decreases firms' knowledge spillovers, which weakens firms' incentives to free-ride on each other and forces firms to step up their individual R&D efforts. In full delegation, firms are located closer, two opposite effects come into play sharply. Lower level of differentiation forces firms charge lower prices, while diluted R&D competition leads to less R&D investment. Evidently, firms with full delegation spend less on R&D due to sufficiently "large" spillover effect, while firms with partial delegation have to spend more on R&D because of "small" spillover effect.

4.3. Quality

Result 4. $X^P > X^N > X^F > 0$

Two factors affect the quality index "X": the one is the spillover effect which is endogenously characterized by owners' locational decisions; the other one is the R&D efforts of two competing firms, chosen by owners under no and partial delegation, particularly chosen by managers under full delegation. Obviously, the former factor is completely controlled by owners, however, the latter one could be deter-

mined by managers. Product quality is higher if owners control both factors, while quality is lower if managers decide on the R&D factor. Furthermore, combined with Result 1, we deduce that from the perspective of product differentiation, partial delegation generates higher product variety and higher product quality, by contrast, full delegation leads to lower variety and lower quality.

4.4. Incentive scheme

Result 5. $\theta^P < \theta^F$

Under partial delegation, the incentive contract θ_i just affects the subsequent price decision, higher value of θ_i gives rise to a lower price p_i, because manager tends to put more stress on the market share. The rival firm j moves far away from the market center to escape tougher competition resulting from the higher value of θ_i. Since the strategy is complementarity, on anticipating this fact, each owner will set a lower incentive scheme parameter to mitigate the subsequent price competition.

Under full delegation, the incentive contract θ_i plays an important role not only at the price stage but also at the R&D stage. Higher value of incentive parameter leads to lower price p_i and stronger R&D effort X_i, because manager tends to attach more importance to market share. This lower price p_i and stronger R&D effort X_i will influence owners' location choices. Two firms tend to move far away towards the endpoint of market to soften the price competition, but they expect they can benefit more R&D effort exerted by his rival from closer locations. Due to these two conflicting effects, owners will decide a higher value of incentive scheme θ^F (compared to θ^P) by anticipating the aforementioned fact.

4.5. Price

$$p^P > p^N \geq p^F > 0 \quad t \in (t, \underline{t}]$$

Result 6. $p^P > p^F \geq p^N > 0 \quad t \in (\tilde{t}, \bar{t}]$

$$\tilde{t} = 0.31018 \frac{1}{\gamma}$$

Partial delegation generates the highest level of price. The reason is two-fold: first, weakening of price competition because of large distance between firms; on the other hand, due to weak spillover extent, firm benefits less from its rival's R&D effort so that the firm has to invest more on R&D. Since R&D effort is costly, managers ought to increase price in order to compensate for excessive spending. Consequently, price is the highest under partial delegation scenario.

The ambiguous relationship between p^N and p^F is caused by two conflicting effects: one is that, following an increase of distance between firms, price competition becomes soft, the decreasing spillover weakens the R&D free-ride and forces firms carry on more individual R&D efforts. The softened price competition and costly R&D efforts boost the equilibrium price. Thus, the price is reduced by the decreasing distance between firms. The other one is the effect of delegation which renders managers less aggressive, increases the price due to negative value of incentive parameter. Precisely, the increase of transportation cost generates the diminution of incentive parameter value, in turn, strengthens this delegation effect. From the equilibrium location under no delegation to the one under full delegation, the distance between competing firms is shortened, accordingly, the former effect diminishes the price but the latter has the price increased.

When transportation cost is sufficiently large, the delegation effect will prevail over the aggregate influences of softened price competition and costly R&D efforts, thus, the equilibrium price under full delegation can be higher.

4.6. Profit

Result 7. $\pi^P > \pi^F > \pi^N > 0$

First, we focus on the inequality $\pi^P > \pi^F$. Owners, by using an incentive contract strategically, direct their managers to a less aggressive behavior in order to soften price competition and increase product price. Since the value of incentive scheme under partial delegation is lower than that under full delegation (Result 5), the equilibrium price in partial delegation case will be higher (Result 6). When owners delegate long-run R&D decisions to their managers, they spur them to enhance product quality, in other words, to conduct more effective R&D efforts realized by two channels: more investment and closer location. A firm decides to draw a rival closer in order to benefit more via spillovers at no cost (Result 1) instead of investing more on own R&D (Result 3), thus firms economize the cost on R&D. Nevertheless, the gains from the rise of price caused by partial delegation are much higher than the gains from economizing the cost of R&D under full delegation. Consequently, the partial delegation strategy is always more profitable compared to full delegation.

Although the equilibrium price under full delegation is not always higher than price in the benchmark case (Result 6), managerial firms in full delegation are more profitable than entrepreneurial firms on all occasions. This is because the gains from full delegation largely in the form of free-ride effect on R&D, prevail over the losses from intensified price competition. What firms economize in terms of R&D investment sufficiently compensates the losses from lower price due to furious price competition. Thus, the full delegation strategy is more profitable than no delegation.

5. Consumer surplus and social welfare

Partial delegation is the most profitable strategy. We reflect on the analytic outcomes of the rest of important economic indicators and investigate whether such a strategy may also increase consumer surplus or social welfare. It is thus interesting to compare the equilibrium ownership structure with socially most preferred ownership structure, in order to establish the correspondence between social and private incentives for strategic delegation.

Let "CS" denote consumer surplus[4] and "W" represent social welfare. Consumer surplus and social welfare are given by

$$CS = \int_0^{D_i} [\nu - p_i - t(y - y_i)^2 + X_i]dy + \int_{D_i}^1 [\nu - p_j - t(y_j - y)^2 + X_j]dy$$

$$W = \int_0^{D_i} [\nu - t(y - y_i)^2 - \tfrac{1}{2}x_i^2]dy + \int_{D_i}^1 [\nu - t(y_j - y)^2 - \tfrac{1}{2}x_j^2]dy$$

We highlight the composition of CS and W for different scenarios in Appendix A.

Result 8. $CS^N > CS^F > CS^P$ *and* $W^N > W^F > W^P$

Combined with the analysis in terms of profits (Result 7), we demonstrate that delegation schemes are profitable for firms, however they are never beneficial to consumers. Full delegation is an efficient strategy generating the highest level of social welfare. In partial delegation case, high price certainly leads to the decrease of consumer surplus and aggregate surplus, in spite of high product quality.

[4] The effective R&D "Xi" is transformed into consumer's value, that is interpreted as quality (enhancement).

When owners direct managers to make short-run price decisions, this type of delegation will increase product variety (horizontal differentiation), foster firms to spend more on R&D, encourage firms to produce high-quality goods and render manager be less aggressive, hence increase prices and profits. Because of the high level of horizontal differentiation, to some extent that firm would be less likely to conduct research in common areas and owners adopt firm-specific R&D investment. This spending on R&D generates less synergy and results in vast R&D costs. Consequently, both consumer surplus and social welfare decrease, and they are inferior to standard levels (no delegation). This is the sharp conflict between private profits and collective gains under partial delegation.

On the contrary, under full delegation owners choose a closer location pattern. The impact of owners' locational decisions is two-fold: first, it determines lower horizontal differentiation; second, it reflects the high level of spillover. A high level of spillover causes firms to free-ride on their rivals' R&D, and erodes their incentive to conduct competitive R&D. Thus, firms have less interest to improve product quality. It is detrimental to consumer surplus on the one hand, while being propitious to firms on the other. Lower level of horizontal differentiation forces firms to face intensified price competition so that firms cut down prices. This benefits consumers on a large scale, and then enhance social welfare. We highlight that full delegation is a more efficient strategy, which not only brings on the profits but improves social welfare as well.

6. Concluding remarks

This framework focuses on the issue of strategic delegation in the presence of both endogenous product differentiation and endogenous R&D spillovers. This model provides important implications for the real practice of delegation. Within this framework, linear combination of firm's profit and its market share is regarded as managers' objectives, and owners decide the firm's location pattern and whether to delegate the tasks or not.

The existing literature on strategic delegation with R&D considers that firm's owners alternative decisions are either full delegation, or no delegation. We introduce the scenario "partial delegation" where firms' owners delegate short-run decisions and retain long-run decisions themselves. Our analysis shows that partial delegation encourages one firm to locate farther from the rival and firms could locate at the two respective extremities of the market. Partial delegation increases product differentiation, fosters firms spend more on R&D, encourages firms to produce high-quality goods and renders managers be less aggressive, hence increases prices and profits. However, both consumer surplus and social welfare decrease. On the contrary, full delegation can improve social welfare, and it is more profitable than no delegation.

In addition, there are several possible extensions we find worth pursuing, e.g., (1) whether the obtained outcomes are verified in oligopoly game, (2) different costs of carrying out R&D affect the benefits of delegation, (3) the effect of different performance measures (relative profit, output, sales etc.) can be studied in this framework.

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Appendix A

No delegation:

$$CS^N = \frac{\gamma(t(-3\gamma(t(-81t\gamma\sqrt{3t\gamma(3t\gamma+2)}+243t\gamma(t\gamma+2)+92-24\nu)+405t\gamma\sqrt{3t\gamma(3t\gamma+2)}+140)+48\nu)-72t\gamma\sqrt{3t\gamma(3t\gamma+2)})}{24\gamma(3t\gamma+2)}$$

$$W^N = \frac{t(54t\gamma\sqrt{3t\gamma(3t\gamma+2)}-\gamma(3t(\gamma(-81t\gamma\sqrt{3t\gamma(3t\gamma+2)}+27t(\gamma(9t\gamma+2)+2)-16)+18)+27t\gamma\sqrt{3t\gamma(3t\gamma+2)}+4))}{24\gamma(3t\gamma+2)}+\upsilon$$

Partial delegation:

$$CS^P = \frac{\gamma(t(-5\gamma(t(-375t\gamma\sqrt{5t\gamma(5t\gamma+4)}+75t\gamma(25t\gamma+64)+1568)-96\upsilon)+4050t\gamma\sqrt{5t\gamma(5t\gamma+4)}+1888)+384\upsilon)-480t\gamma\sqrt{5t\gamma(5t\gamma+4)}}{96\gamma(5t\gamma+4)}$$

$$W^P = \frac{-9375t^4\gamma^4+2t(\gamma(-75t\gamma\sqrt{5t\gamma(5t\gamma+4)}+240\upsilon\gamma-16)+300t\gamma\sqrt{5t\gamma(5t\gamma+4)}-3000t^3(\gamma+1)\gamma^2+5t^2\gamma(\gamma(375t\gamma\sqrt{5t\gamma(5t\gamma+4)}+112)-240)+384\upsilon\gamma}{96\gamma(5t\gamma+4)}$$

Full delegation:

$$CS^F = \frac{3(-4374t^5\gamma^5-19440t^4\gamma^4-280t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+9t^3\gamma^3(27t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}-3778))+19600\upsilon\gamma}{100\gamma(9t\gamma+14)^2}$$

$$+\frac{t(9t\gamma(891t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+2700\upsilon\gamma-12379)+2889t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+75600\upsilon\gamma+93380)}{300\gamma(9t\gamma+14)^2}$$

$$W^F = \upsilon-\frac{3t(4374t^4\gamma^5+11664t^3\gamma^4+t\gamma^2(-459t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+2862t-3395)-117t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121})}{100\gamma(9t\gamma+14)^2}$$

$$-\frac{t(81t^2\gamma^2(-27t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+108t+754)-486t^2\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+945t\gamma\sqrt{324t^2\gamma^2+504t\gamma+121}+22167t+4900)}{300\gamma(9t\gamma+14)^2}$$

References:

Bacena-Ruiz, J.C., Olaizola, N. (2006). Cost-saving production technologies and strategic delegation. Australian Economic Papers, 45: 141–157.

Barcena-Ruiz, J.C., Espinosa, M.P. (1996). Long-Term or Short-Term Managerial Incentive Contracts. Journal of Economics and Management Strategy, 5: 343–359.

Boyd, C. (1990). Cases in strategic management and business policy, McGraw-Hill, New York.

Cohen, W.M., Levinthal, D.A. (1990). Absorptive capacity: a new perspective on learning and innovation. Administration Science Quarterly, 35: 128–152.

D'Aspremont, C., Jacquemin, A. (1988). Cooperative and noncooperative R&D in duopoly with spillovers. American Economic Review, 78: 1133–1137.

Dey, S., Fu, Q. (2009). Do firms value knowledge spillover? A model of R&D competition, endogenous R&D appropriability and product differentiation, Working paper.

Fershtman, C., Judd, K.L. (1987). Equilibrium incentives in oligopoly. American Economic Review, 77: 927–940.

Fershtman, C., Judd, K.L., Kalai, E. (1991). Observable contracts: Strategic delegation and cooperation. International Economic Review, 32: 551–559.

Henriques, I. (1990). Cooperative and Noncooperative R&D in Duopoly with Spillovers: Comment. American Economic Review, 80: 638–640.

Jaffe A.B. (1986). Technological opportunity and spillovers of R&D: evidence from firms' patents, profits and market value. American Economic Review, 76: 984–1001.

Kamien, M.I., Muller, E., Zang, I. (1992). Research joint ventures and R&D cartels. American Economic Review, 82: 1293–1306.

Kamien, M.I., Zang, I. (2000). Meet me halfway: research joint ventures and absorptive capacity. International Journal of Industrial Organization, 18: 995–1012.

Katsoulacos, Y., Ulph, D. (1998). Endogenous spillovers and the performance of research joint ventures. Journal of Industrial Economics, 46: 333–357.

Katz, M.L. (1991). Game-playing agents: unobservable contracts as precommitments. Rand Journal of Economics, 22: 307–328.

Lepape, N., Zhao, K. (2011). R&D Appropriability and Products Substitutability: Should firms cooperate or not? TEPP-GAINS, Working paper.

Mitrokostas, E., Petrakis, E. (2005). The Scope of Strategic Delegation in Oligopoly. Working Paper.

Peck, M.J. (1988). The Large Japanese Corporation. In: Meyer, J.R., Gustafson, J.M. (eds). The U.S. Business Corporation: An Institution in Transition, Cambridge MA: Ballinger, 35–36.

Piga, C.A., Poyago-Theotoky, J. (2005). Regional Science and Urban Economics, 35: 127–139.

Schelling, T.C. (1960). The strategy of conflict. Harvard University Press.

Sklivas, S.D. (1987). The strategic choice of managerial incentives. Rand Journal of Economics, 18: 452–458.

Vickers, J. (1985). Delegation and the theory of the firm. Economic Journal, Supplement, 95: 138–147.

Welch, J. (2003). Straight From the Gut. Published by Warner Books, Inc.

Zhang, J., Zhang, Z. (1997). R&D in a strategic delegation game. Managerial and Decision Economics, 18: 391–398.

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