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Kai Zhao

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Theoretical contributions on horizontal agreements and R&D spillovers

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Présentée et soutenue publiquement par

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10 Juillet 2012

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THEORETICAL CONTRIBUTIONS ON HORIZONTAL
AGREEMENTS AND R&D SPILLOVERS

A Thesis in
University of Maine
by
Kai ZHAO

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor in Economics

10 July 2012

L'université du Maine n'entend donner aucune approbation ni improbation aux opinions émises dans cette thèse. Ces opinions doivent être considérées comme propres à leur auteur.

Preface

Market power and profit are the legitimate reward for the fact that a given firm has been more successful than others. Call this situation where a firm acquires market power and grows on the merit “internal (organic) growth”. Contrast it with a situation - call it “external (inorganic) growth” - where a firm grows not because of its investment, but simply because it takes over other firms (or merges with them).

Organizations consider horizontal M&As as the external mode of expansion, and regard R&D as one of the most efficient internal expansion modes, to achieve and maintain sustainable growth. This thesis pursues the firm growth’s tactic to trace the impact of two aforementioned expansion modes on firm’s performance and profitability. Therefore, this dissertation is divided in two main parts. First part (Chapter 1 and Chapter 2) offers detailed analysis of inorganic M&A expansion mode: horizontal mergers and merger control in national and international prospective. Second part (Chapter 3 and Chapter 4) studies the organic R&D: R&D with spillovers in collusion and delegation contexts.

Chapter 1 extends the strand of literature on horizontal mergers in a homogeneous oligopoly where there are leaders and followers. Within sequential output decisions, we focus upon the cost uncertainty and the efficiency gains (or losses), in order to fulfill the gap of merger issue. There are three phases in merger game (*Pre-merger*; *Merger*; *Post merger*). The firms’ incentive to merge is examined in *merger* phase where no firm knows the actual productivity change of merged entity, including the participants (merging firms). It is shown that the expected profit of merged firm grows following the enlargement of variance on the cost. When the extent of variance exceeds a certain threshold, firms facing uncertainty choose to merge. On the other hand, if there is role redistribution, even in the absence of uncertainty effect, firms have incentives to merge. Without loss of generality, the profitability of merger is analyzed in the *post merger* phase where part of firms learn the actual change of merged firm in productivity. We find that the two-follower merger aiming to a leader strategy occurs more likely than the one

satisfying *statu quo*. Furthermore, the merged firm has interests to pool the private signals to outsiders, in the absence of role redistribution. By contrast, in the presence of role redistribution, the concealment is more profitable from the viewpoint of insider. In terms of “Merger Approval”, we emphasize the timing of regulation intervention (*ex ante* or *ex post* enforcement) and distinguish two different merger control criterions (Consumer welfare standard or Total welfare standard). Since prudent Competition Authorities should take the restrictive policy, our framework illustrates why US Horizontal Merger Guidelines and EC Merger Regulation are biased in favor of the consumers’ interests.

Chapter 2 provides a game-theoretic approach to explain FDI and export activities, analyze both the “entry mode choice” and “target firm selection” decisions. Furthermore, the issues of foreign firm’s preference and host government’s judgment are tracked. In such a context, analyzing the optimal entry mode involves not only a standard firm’s private incentive study, but also an analysis of the strategic interaction between the foreign firm and the host government which is regarded as a screening device to foreign firm’s entry mode decision. The clash between the foreign firm’s equilibrium choice and the host government’s preference can provide a rationale for some frequently observed market access restrictions. A main result of our analysis is the foreign firm being technologically advantaged has a stronger incentive to choose cross border M&A, rather than greenfield investment or exporting, moreover, it prefers acquiring the low-productivity firm when the integration ability is strong and the technological gap is sufficiently small. This study also highlights the ambiguity between the foreign firm’s preference and the government’s judgment under greenfield investment threat, and the unanimity under export threat in certain situations. This private-collective conflict may be fruitful to inform government policies toward international trade.

Chapter 3 studies the significative relevance of the scenarios where firms can either coordinate their decisions or adopt non-cooperative strategy at each stage (Full Competition, Full Collusion and Semi-collusion regimes). The key feature of this framework is to consider that the extent of product substitutability determines the ability of a firm to appropriate the R&D effort of its rival. In addition, this ability is accurately adjusted by the sensibility of spillovers relative to product differentiation which permits us to touch upon the issue of concavity and convexity. We demonstrate in fact which regime generates more R&D effort in equilibrium depends upon both the degree of product differentiation and the technological proximity. In case of the concave relationship between differentiation and spillovers (firms in cluster, *e.g.*, Silicon Valley), competitions at the upstream stage depress R&D investment, and firms colluding in R&D regardless of their production strategy always yield more profit and generate higher social welfare than firms colluding in output (independently of R&D strategy). Within the repeated game, we find that partial collusion is more sustainable than full collusion. Fur-

thermore, R&D cooperation stabilizes the collusion when products are sufficiently differentiated and the technologies are comparatively removed. In addition, the discussion about antitrust policy is carried out. By focusing upon the distinctness of different antitrust criteria, this framework sheds light on the looseness of total welfare standard and the preciseness of consumer surplus standard.

Chapter 4 studies the issue of strategic delegation in the presence of endogenous product (horizontal and vertical) differentiation and endogenous R&D spillovers. Within this framework, the linear combination of firm's profit and its market share is regarded as managers' objectives, and the owners decide the firm's location pattern and whether to delegate the tasks (such as long-run R&D investment, short-run price) or not. By introducing an interesting and realistic scenario "Semi-Delegation" where owners delegate the short-run decisions and retain the long-run decisions themselves, and comparing it with Full Delegation game, we show that: Semi-Delegation increases product differentiation, fosters firms to spend more on R&D, encourages firms to produce high-quality goods and renders managers less aggressive, hence increases prices and profits. Although there are three Nash equilibrium strategy profiles to this delegation game, the *Pareto* optimal solution is that both firms choose Semi-Delegation.

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List of Symbols

a	Size of market
c	Marginal cost and expected cost
c_i	Real marginal cost of merged entity; domestic firm's cost
n	Number of firms
m	Number of leaders
p	Price
Q	Aggregate output
q	Individual output
π	Profit
CS	Consumer surplus
PS	Producer surplus
W	Aggregate (social) welfare
$\Delta_{\mathbb{E}[\pi]}$	Private incentive to merge
Δ_{π}	Profitability of merger
$\Delta_{\mathbb{E}[W]}$	Yardstick judging whether the merger improves the social welfare in expected terms
Δ_W	Difference between the level of welfare before and after merger
σ^2	Degree of uncertainty
σ_{π}^2	Threshold of variance to ensure the profitable merger in expected terms

σ_W^2	Threshold of variance to ensure the welfare-enhancing merger in expected terms
δ	Difference between the merged firm's actual cost and pre-merger firm's cost; common discount factor
δ_{sup}	Ceiling value of δ (which separates profitable from unprofitable mergers)
δ_{inf}	Floor value of δ (below which outsiders are ruled out of the market)
δ_{Wsup}	Upper bound of Δ_W
δ_{Winf}	Lower bound of Δ_W
U	Consumer utility
γ	Product differentiation (substitutability); measure of effectiveness of R&D
I	Numeraire good
x	R&D effort
β	Extent of spillovers
h	Technological proximity
ΔS	Difference between the social optimum and the level of R&D effort
s	Technological gap
t	Trade cost; transportation cost
f	Fixed cost in building new plant (sunk cost)
μ	Acquisition price
θ	Integration ability; incentive parameter
y	Firm's location
λ	Endogenous spillovers
X	Product quality (effective R&D effort)
$\bar{\delta}^T$	Critical value of the discount factor of type T
$\pi_i^{T,D}$	Deviation payoff for collusion type T
$\pi_i^{T,*}$	Collusion payoff for type T

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*Kai Zhao
Le Mans, April 2012*

Dedication

This thesis is dedicated to my parents for their endless love, support and encouragement, and my friends who have supported me all the way since the beginning of my studies.

Also, this thesis is dedicated to my fiancée who has been a great source of motivation and inspiration.

Finally, this thesis is dedicated to all those who help me.

General Introduction

This thesis is a collection of theoretical essays in the area of horizontal M&As and R&D with spillovers. As we know, organizations consider horizontal M&As as the external mode of expansion, and regard R&D as one of the most efficient internal expansion modes, to achieve and maintain sustainable growth. This thesis pursues the firm growth's tactic to trace the impact of two aforementioned expansion modes on firm's performance and profitability. The dissertation is divided into two parts, which respectively focus on the following issues:

Part I: (competitive effects of external growth strategies)

Horizontal M&As generate cost variation *via* uncertainty (Chapter 1) or *via* technological transfer (Chapter 2). We aim to study different types of horizontal M&A and find out which one is the most profitable from the *national* perspective, and to verify whether the M&A entry option is more efficient compared to others, such as greenfield FDI and exporting, from the *international* perspective.

Part II: (competitive effects of internal growth strategies)

R&D effort contributes to cost reduction (Chapter 3) or to quality enhancement (Chapter 4), and it can be beneficial to other firms at no cost due to spillover effect. By considering the long-run R&D decision and the short-run price (or quantity) decision, we attempt to distinguish between full and partial regimes in terms of collusion (Ch.3) or delegation (Ch.4), and to illustrate whether firms have incentive to adopt partial regime.

Background

Growth strategy is divided into two types: internal (organic) growth and external (inorganic) growth. The former is to grow organically by increasing sales personnel, hiring skilled managers and by developing new products, particularly by investing in R&D. The latter one is external growth which concerns, for example, strategic cooperation, alliances, cartel and joint ventures. M&As are an inorganic example of how a company can grow (Sherman, 2005).

Inorganic growth

M&As are an important feature of firm's growth. In an early UK and US study, Evely and Little (1960) and Hannah and Kay (1977) emphasize the important role played by M&As in increasing the concentration and growth of industry. There are several possible motives or reasons why firms choose to grow by M&A. The most common motive is to create synergy but other motives are diversification, improved management, market power, informational advantage and product rationalization (Gaughan, 2002 ; DePhamphilis, 2005; Zhou, 2008b).

M&As have become increasingly international. Cross border M&As account for a significant and growing share of total M&A activity. They now make up around 25% of worldwide M&As, considerably more in the European Union. Between 1996 and 2005, the annual average value of cross border M&As worldwide was 533 billion dollars, or about 70% of annual world FDI flows (UNCTAD, 2006). Since cross border M&As become increasingly popular, it is more and more important to study M&As in an international perspective.

Organic growth

Firms can invest in R&D to realize growth. The two main functions of R&D are on the one hand invention enhancement within firm (Rosenberg, 1990), on the other hand the ability improvement to understand and absorb knowledge from outside the firm (Cohen and Levinthal, 1989).

Many studies claim that R&D activity has a positive impact on firm's growth, particularly from the empiric viewpoint¹. From the IO perspective, R&D activities are also regarded as a significant factor to ameliorate the firm's performance. There are several incentives highlighting the importance of R&D: 1. *profit incentive*, firms may undertake R&D activities to enhance their profit by pursuing product and process innovation. 2. *strategic advantage*² over their rivals, firms spend on R&D to enhance their market share. 3. *absorbable incentive*, firms engaging in R&D aim to developing and maintaining their broader capabilities for the assimilation and absorption of externally available innovation.

By following the trace of growth strategy, the current thesis highlights the important role of both inorganic and organic strategies from the viewpoint of IO. We draw attention to the influence of these strategies, not only on private firm's performance and profitability, but on collective welfare as well. The first part focuses on the inorganic horizontal M&As, and contributes to the theoretical analysis of the causes and consequences of horizontal M&As. In the second part, by emphasizing the R&D and the spillover effect, we proceed the comparison between partial and full regimes within the multi-stage frameworks, respectively in contexts of collusion and delegation.

¹Numerous studies maintains that firms with a strong commitment to R&D tend to have a higher growth rate than firms with a weaker commitment. The German panel results by Schreyer (2000) show that the share of firms that are qualified as "growers" increases with the intensity of R&D activities. Del Monte and Papagni (2003) prove growth rates to be positively correlated with the research intensity. They show that sales growth of firms performing R&D is higher than the growth of firms without performing R&D. In line with this, Adamou and Sasidharan (2007) study the impact of R&D by using panel data on Indian manufacturing firms. They argue that R&D is an essential determinant of firm growth and find that an increase in current R&D induces higher growth irrespective of the industry.

²Indeed, if a firm knows that its rivals are engaging in R&D, it will see its own competitive position as being a threat (competitive threat). In a same vein, a firm failing to maintain a current position and being replaced by a rival will suffer a loss (replacement effect).

Research statement

Part I: National and international M&As with cost variation

M&As have evolved in five trends and have always generated the important debate among policymakers, academics and the public about their causes and consequences. The IO literature³ has provided a number of explanations as to why mergers occur. For example, the increased market power and the benefit from economies of scale should increase the profitability of the merging firms. However, these explanations are not well consistent with the real facts. In practice, M&As are hardly privately profitable. Internet service provider America Online and media giant Time Warner illustrate “one of the biggest failures in merger history”.

In the first part of thesis, we draw attention to M&As between competitors, *viz* horizontal mergers. Horizontal mergers generally soften the market competition, and hence potentially lead to higher prices for consumers which imply transfers of wealth from consumers to producers. Consequently, most countries establish Competition Authorities which scrutinize the mergers. However, horizontal mergers are not illegal *per se*, because mergers may allow firms to realize synergies emerging in the form of reallocation of production across firms, knowledge transfer . . . , they could also generate the uncertainty or the informational advantage, which may provide a stronger incentive to merge for participants. Such efficiency gains/losses and uncertainty effect can be weighed against/for the anti-competitive aspects of the merger.

Cross border M&As have the same problem as aforementioned ones but to a higher degree because of the unfamiliarity in each other’s environment and culture (Sudarsanam, 1995). There are several reasons why we focus on horizontal mergers from an international perspective. Cross border M&As fuel the growth in international production and even accelerate the growth pace. In addition, cross border M&As pose challenges for competition policy. Such mergers affect several

³See Charl  ty and Souam (2002), Nocke and Whinston (2010). They provide a comprehensive review of the published research in horizontal mergers.

countries and are hence subject to review by different national Competition Authorities. Different authorities may generate conflicting conclusion, for instance, General Electric (GE) and Honeywell was approved by US antitrust agencies but ultimately blocked by the European Commission (Grant and Neven, 2005).

In contrast with national M&As, the main motive for cross border M&As is to establish a market presence abroad. Compared to the alternative foreign-market-entry modes, such as exporting and greenfield investment, cross border M&As attempt enhancing industry concentration, thereby potentially damaging consumers and benefiting local competitors. However, they also provide additional efficiency advantages. These include the avoidance of setup costs and of the fixed costs of operating a production facility arising in the case of greenfield FDI, and the avoidance of transportation costs and trade barriers associated with exporting. Investing abroad, the firm must possess some asset (for example, product and process technology or management and marketing skills) that can be used profitably in the foreign affiliate. Consequently, there are distinctive kinds of firms in international market, and the distinctive characteristics⁴ are pivotal when analyzing the impact of foreign direct investment on host countries. The foreign firm's entry represents something more than a simple import of capital into a host country, which is studied in models rooted in traditional trade theory⁵ (Blomström and Kokko, 1996).

The work presented in this part of the thesis contributes to the theoretical analysis of the causes and consequences of horizontal mergers. In the first chapter,

⁴ This distinction is particularly important for developing countries, where domestic enterprises are likely to be relatively small, weak, and technologically backward. These countries also differ from the developed ones in such aspects as market size, degree of protection, and availability of skills. The foreign firm entry may therefore have effects, both positive and negative, which are substantially different from those that occur in developed host countries (Blomström, 1996).

⁵ Although the traditional trade theory approach and the industrial organization approach are not mutually exclusive, they have so far generally emphasized different aspects of capital movements. Trade theorists have mainly been interested in the direct effects of foreign investment (direct as well as portfolio investment) on factor rewards, employment, and capital flows, while those following the industrial organization approach have put more emphasis on indirect effects or externalities. In this study, we adopt an industrial organization approach, and focus on issues related to the transfer and diffusion of technology and knowledge, as well as the impact of FDI on market structure and competition in host countries.

we reconsider the market power-efficiency tradeoff in the presence of role distribution, and modify the standard assumption of deterministic product markets to study features that are relevant in uncertain environments. In the second chapter, we formalize the **market entry strategy** (Export, Greenfield investment, Cross border M&A) and the **target selection** (Acquisition of high-productivity firm or low-productivity one for a foreign firm). This framework in open economies permits us to study the relationship between foreign firm's incentive and host government's intention.

Chapter 1: National horizontal M&As

The first chapter broadens the theory on horizontal mergers with uncertain efficiency gains in Stackelberg markets. In general, there are three phases in merger game: I. pre-merger, II. merger, III. post merger. Some path-breaking work on horizontal mergers takes efficiency gains for granted, or assumes that firms have perfect knowledge about the future merged entity when taking merger decisions. In practice, merging firms and Competition Authorities⁶ could not know the exact future efficiency gains (or losses) prior to merger consummation, in other words, the possibility that the merging firms become more efficient does not mean that these gains are actually realized once the operation has been cleared and has taken place. This is because merged firms are not just larger firms but more complex organizations.

The key factor of this chapter is that the merger creates uncertainty on the productivity and informational asymmetry between firms. The firms' incentive to merge is examined in *merger* phase where no firm knows the actual productivity change of merged entity, including the participants (merging firms). Without loss of generality, the profitability of merger is analyzed in the *post merger* phase where part of firms learn the actual change of merged firm in productivity. Concretely, insider *first-to-knows* its own productivity, and outsider-followers, by perfectly observing the output level of merged firm (if behaving as leader) can infer the exact

⁶Merging firms in general have strong incentives to overestimate these gains in front of Competition Authorities.

value of merged firm's cost (or productivity).

Obviously, the behavior of merged entity can alter the outsider firms' information configuration: leader strategy chosen by insider generates the asymmetric information amongst non-merged firms, and there will be the symmetric information amongst outsiders when insider behaves as a follower. Furthermore, the results in an uncertain surroundings and the outcomes in a deterministic environment with perfect information are compared, this allows us to study whether the merged firm has interest to reveal the information about its own cost to competing firms.

In order to capture the impacts of role distribution, information configuration, cost uncertainty and antitrust enforcement, we consider all possible bilateral mergers: merger between leaders (or followers), merger between leader and follower, and merger between followers resulting in merged leader firm. In terms of merger control, we emphasize the different timing of regulation intervention (*ex ante* or *ex post* enforcement) and distinguish two merger control criterions (Consumer welfare standard or Total welfare standard). This framework gives a potential explanation for merger failures, and illustrates why US Horizontal Merger Guidelines and EC Merger Regulation are biased in favor of the consumers' interests.

Chapter 2: International horizontal M&As

The second chapter incorporates, in an entry mode choice and target firm selection context, firms' concern about technology and integration ability. The purpose of this chapter is to formalize the choices of market entry strategy and the target selection for a foreign firm, and to delineate the relationship between foreign firm's incentive and host government's intention.

Exporting is a traditional way to serve host markets. As exporting is direct sale of domestically-produced goods in foreign country, no investment in host production facilities is required. The costs associated with exporting take the form of transportation expenses. Foreign Direct Investment is the direct ownership of facilities in the target country, and involves the transfer of resources in terms of

capital, technology and personnel. FDI may be made through the acquisition of an existing entity (cross border M&A, nickname Brownfield investment) or the establishment of a new enterprise (Greenfield investment). The key aspect of chapter 2 is how the entering firm's advanced technology is transferred. The new plant constructed by foreign firm *via* greenfield investment can fully use the foreign firm's superior technology, however, the superior (or advanced) technology will be partially transferred to the local acquired firm. We emphasize the word "partially", because the newly acquired firm's productivity will be in-between the productivity of the two firms participating in M&A, and depends upon the technological gap, the post-acquisition integration ability.

Apart from discussing three alternative entry modes, we regard the main contribution of this chapter as being two-fold. First, while most of the existing models (Görg, 2000; Kim, 2009; *etc*) on cross border M&A do not focus on the target firm selection (since they simply assume domestic firms are identical), this chapter considers a target choice process when several domestic firms accept the M&A proposal. This allows us to investigate how the relevant factors, such as technology transfer, affect the acquisition target selection. Second, we incorporate active host government judgment within our entry mode choice framework. In particular, consistent with what happens in most countries (such as US and UK), we assume that the foreign firm must notify project to government in host country, which can either authorize or block the foreign firm's plan. The host government decision is taken in order to authorize the entry mode which improves the most welfare of host country measured by the sum of consumer's surplus and domestic firm's profits, and acquisition payment in case of M&A. In such a context, analyzing the optimal entry mode involves not only a standard firm's private incentive analysis, but also a study of the strategic interaction between the foreign firm and the host government which is regarded as a screening device to foreign firm's decision. The clash between the foreign firm's equilibrium choice and the local government's dominance preference can provide a rationale for some frequently observed market access restrictions⁷.

⁷The US government's scrutiny of cross border M&A has been tightened, some recent attempts of foreign companies to acquire US firms have incited formidable political opposition. Notable examples include Dubai's PortsWorld's bid to manage five US ports in 2006 and CNOOC's offer

In the debate on the role of foreign firm in international technology transfer, it has sometimes been suggested that the significant channels for the dissemination of modern, advanced technology are external effects or “spillovers”, rather than formal technology transfer arrangements (Blomström, 1989). Therefore, in part II, we carry on the in-depth analysis on the R&D and the spillovers being omnipresent in R&D area.

Part II: Collusion and Delegation under R&D spillovers

Empirical evidence discloses the incontestable contribution of R&D to firm’s performance. More and more firms tend to invest in R&D to beat competitors and innovate in order to continuously maximize shareholder value. During 2000-2006, the 10 largest US companies increased their R&D spending by 42%. In addition, numerous empirical studies⁸ reveal that innovation in the form of development of product quality enhancing and cost reducing processes facilitates firms to achieve a competitive advantage in the market.

The most important aspect of R&D is externalities (or spillovers) which has been studied through the divergence between the social and private returns of production process. The public goods feature of knowledge generates spillovers which allow others to use the owner of an innovation free of charge. Due to the spillover effect, the rate of return from an innovation is lesser and as a result, the incentives for carrying out R&D are reduced. The individual firm fears that competitors use its internal research results and thus probably increase their profits without having to bear the expenses. Therefore, the researching firm will only have limited incentive to invest in R&D. However, from the collective viewpoint, spillovers spur the dissemination of new knowledge available for the whole society, and improve the social welfare.

to acquire Unocal in 2005.

⁸Del Monte and Pagani (2003) offer a comprehensive literature review on the subject.

In the current part, we consider R&D as the long-term activity which can reduce the production cost (Chapter 3) or enhance the product quality (Chapter 4). We study whether firms have interest to undertake R&D cooperation in Chapter 3 and whether firms have incentive to delegate the long-run R&D decision to managers in Chapter 4, under two innovative designs about spillovers.

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. In these papers, spillovers are considered as “manna from heaven”, which refer to a fixed and exogenously given portion of every firm’s process. In this part, we investigate the extent to which R&D spillover effects are intensified by both technological⁹ (Chapter 3) and geographic¹⁰ (Chapter 4) proximities between spillover generating and receiving firms. To this end, we use two different methodologies to construct the R&D spillovers: i) (exogenous) technological proximity and product differentiation; ii) (endogenous) geographic distance. The approach for modelling technology based R&D spillovers builds on the methodology emphasizing the relationship amongst the extent of spillover, the degree of product differentiation, and the convex-concave technological proximity. Locational R&D spillovers rest on the geographical distances between firms which can be controlled by either owners or managers in fully or partially delegated manner.

⁹Spillovers are believed to be higher between technological neighbors. According to this view, the ability to make productive use of another firm’s knowledge depends on the degree of technological similarity between firms. Every technology has a somewhat unique set of applications and language. Researchers in similar technological fields will interact in professional organizations, publish in commonly read journals, and, increasingly, browse a common set of web pages. Reverse engineering may be employed to maintain parity with one’s rivals. And spying and corporate espionage are thought to be relatively common among information intensive industries.

¹⁰Firms that are geographic neighbors may exchange knowledge through a variety of channels. Knowledge may be transmitted through employee interaction in social, civic and professional organizations, participation in which may be geographically constrained. Normal employee turnover can result in significant cross-pollination of knowledge stocks. And geographically near firms are likely to share buyers and suppliers who also may serve as conduits for information flow. Knowledge, sensitive to geographic distance, is defined also “tacit” or non-codified knowledge, because it refers to ideas not perfectly codified, but embodied in people.

Chapter 3: Collusion under R&D spillovers

In the traditional one-dimensional framework, collusion increases producer profits, but damages consumer welfare without ambiguity (Textbook¹¹ view). However, this argument ignores the effects of other non-production activities, such as R&D. Recently, as shown in Revisionist¹² view, within two-dimensional game, semi-collusion may be profitable and efficient (Brod and Shivakumar, 1999) under some circumstances, while it can be unprofitable and inefficient (Fershtman and Gandal, 1994; Mukherjee, 2002). Previous works have shown whether producers and consumers would be better off under product market cooperation depends particularly on product differentiation and R&D spillovers.

Compared to aforementioned works¹³, this chapter emphasizes the “close relationship” between product differentiation and R&D spillovers. The key feature of this framework is to consider that the extent of product differentiation determines the ability of a firm to appropriate the R&D effort of its rival. In addition, this ability is influenced by the sensibility of spillovers relative to product differentiation, in other words, technological proximity. To be concrete, electric power companies¹⁴ are differentiated by voltages, a commercial consumer may need a voltage level of 11kv or 440v while a residential consumer needs power at level of 240v, this difference of voltages refers to product differentiation. The electricity can be produced by different technologies (*i.e.*, solar panels, wind turbines, nuclear energy), this refers to technological proximity. The R&D flow between companies employing the same output (voltage) and the same technique, is obviously greater.

From the M&A perspective, in the previous part (**Part I**), we regard the merged firm as a new fully integrated entity. However, the merger analysis in case of dif-

¹¹The textbook view: while the firms benefit from product market collusion, consumer welfare is higher under non-cooperation in the product market.

¹²The revisionist view: if the firms have the options for non-production activities, such as R&D, before production, producers can be worse off and consumers can be better off.

¹³Product differentiation and R&D spillovers are considered as two independent parameters.

¹⁴The Tokyo Electric Power Company (TEPCO) is one of the world’s largest electric utility companies, Japan has ten major regional power companies (Chubu Electric Power Company Inc., Chugoku Electric Power Company Inc. and Kansai Electric Power Company Inc.) but TEPCO alone supplies approximately one-third of Japan’s electricity.

ferent outlets (or products) are maintained *post* merger is similar to an analysis of collusion, as long as other effects, such as production rationalization or scale economies, are not considered. Therefore, horizontal mergers might also be interpreted as a Full Cartel where the participants coordinate their decisions with respect to all of strategic-variables. Thus, it is of interest to ask the question “*How the analysis would change if firms were able to coordinate decisions with respect to partial strategic-variables ?*” There are multi reasons why partial collusion is relevant: the first example (R&D Cartel) refers to fact that antitrust legislation may make price coordination infeasible, or at least difficult. It is logical to assume that the coordination of R&D investment decisions is much less likely to be prohibited by Antitrust Authorities. Another example of partial collusion (Production/Price Cartel) is associated with the situation in which the firms independently make R&D investments, anticipating that two of the firms might collude in the future¹⁵.

In this chapter, we consider a two-stage game where firms with heterogenous products competing in a Cournot fashion engage in upstream R&D and downstream production. At each stage, the competing firms can either coordinate their decisions or adopt non-cooperative strategy. This assumption allows us to analyze the following alternative scenarios: Full Competition, Production Cartel, R&D Cartel and Merger. We demonstrate, in fact which regime generates more R&D effort in equilibrium depends upon both the degree of product differentiation and the technological proximity. When firms use the similar techniques, the ranking of R&D efforts is unalterable and independent of the differentiation degree, competition at the upstream stage depress R&D investment. Firms colluding in R&D regardless of their production strategy always yield more profit and generate more social welfare than firms colluding in output. From the collective viewpoint, Merger is a welfare-enhancing regime in case of close substitutes. Furthermore, we proceed the discussion about antitrust policy, and shed light on the leniency of total welfare standard and the restrictiveness of consumer welfare standard.

In addition, within repeated game it is shown that partial collusion is more sus-

¹⁵In Friedman and Thisse (1993), they analyze a partial collusion in price within a location-then-price game, assuming firms anticipate collusion in price.

tainable than full collusion. R&D cooperation stabilizes the collusion when products are sufficiently differentiated and the technologies are comparatively removed.

Chapter 4: Delegation under R&D spillovers

Conventional wisdom suggests that internal organization has profound effects on firm's productivity, efficiency and growth. The seminal contributions (Coase, 1937; Klein et al., 1978; Williamson, 1985; Grossman and Hart, 1986; Shleifer and Vishny, 1986) have exploited the field which highlights 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 designing of managerial contracts and the incentive for upstream R&D? How owners choose different types of managerial incentives and how does this affect market outcomes? Whether the delegation strategy can improve the consumer surplus and the social welfare, and which one serves best? This chapter attempts to address these questions by studying the location-R&D-price framework.

R&D investment, as modeled here, leads to an increase in products' quality and can have a positive effect on the market share. The magnitude of this effect depends on the degree of substitutability between the products and on the level of spillover of R&D investment results between firms. Moreover, these two mentioned factors are endogenously determined by firm's location in linear (Hotelling) market. Nevertheless, firm owners can use delegation to strategically influence the investment behavior of the manager and to commit the firm to a more or less aggressive behavior on the market.

In d'Aspremont and Jacquemin (1988) and Kamien, Muller and Zang (1992), only the competition effects of R&D investments are analyzed, the internal organization of the firm is not explicitly modeled. This chapter follows a line of research

that received some attention in the last years, using analytical models to investigate the competition effect of R&D investment decisions, when firms choose to delegate control for strategic reasons.

Zhang and Zhang (1997) are the first to extend a strategic delegation game with the possibility of R&D investments, where the manager's compensation contract is based on two performance measures, namely total firm profit and revenues. They place their analysis in a quantity competition setting and find out, that delegation is never beneficial, whenever the manager can invest in production cost reducing process R&D. Bárcena-Ruiz and Olaizola (2006), Mitrokostas and Petrakis (2005) investigate different scopes of delegation in a Cournot duopoly model, discriminating between no delegation, full delegation and short-run delegation, where only market decisions are delegated and owners decide on cost reducing R&D themselves. Unlike Zhang and Zhang (1997), they excluded spillover effects and applied 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, when spillover effects on product qualities are explicitly modelled.

The contribution of this chapter is three-fold. First, we extend the strategic delegation game by introducing the endogenous spillovers. This allows us to study how the ownership structure affects firms' locations¹⁶, R&D as well as their price decisions in the context of both endogenous spillovers and endogenous product differentiation. The second contribution is that we distinguish between two kinds of delegation: Semi-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.

Markets are characterized by both horizontal and vertical differentiations¹⁷.

¹⁶As the literature on spatial competition points out, the location of the firm can also be interpreted as product variety. This literature (see, for example, d'Aspremont et al., 1979) usually considers that firms ought to be located within the city limits.

¹⁷For instance, apparel, garments and shoes have an amazingly rich combination of shapes, colours, materials, complementarities, seasonal and territorial specificities, appropriateness to social events, relative distance to ideals promoted by media, stylists and the show business. The

Vertical differentiation reflects that the competing firms produce distinct quality levels. And horizontal differentiation is characterized by different locations of the firms in a Hotelling linear city; alternatively, it reflects consumers' preferences for different brands in the product space. Within this framework, the location space is considered as the range of product variants; the firms' locations not only indicate the product variety but also reflect the extent of R&D spillovers; a consumer's location corresponds to his ideal product; the transportation cost is interpreted as the decrement of utility from not consuming the ideal product; and the effective R&D effort mirrors the product quality¹⁸.

Our analysis shows that Semi-Delegation encourages one firm to locate farther from the rival and the firms could locate at the two respective extremities of market. Semi-Delegation increases product differentiation, fosters firms to spend more on R&D, encourages firms to produce high-quality goods and renders managers less aggressive, hence increases prices and profits. Although there are three Nash equilibrium strategy profiles to this delegation game, the *Pareto* optimal solution is that both firms choose Semi-Delegation.

quality of the materials can often be seen as a vertical differentiation but some other elements are clearly horizontal, like shapes.

¹⁸ An example of such a quality feature is advertising expenditure, which can be added to any differentiated good. Another example is the speed of calculation of a personal computer. Then the products are computer programs or microchips of quality level, differentiated in variety (location on Hotelling linear city) by the task they perform or the extent in which they are graphics-oriented or keyboard-oriented. All costs of quality improvement are incorporated in the better design of the program or chip and attract more consumers. See also Economides (1989)

Part I

National and international M&As with cost variation

Stackelberg mergers under cost uncertainty

Abstract: *This chapter analyzes horizontal mergers when the output decision-making process is sequential, by the key assumption that mergers create uncertainty on the productivity and informational asymmetry between firms. Horizontal mergers are examined in the context of close relationship between the distribution of roles and the information structure. We demonstrate that if there are more leaders than followers in the industry, then the cost uncertainty level inducing firms to merge is lower in case of leader-merger than follower-merger, and reversely when there are more followers. We also study whether the merged firm has interest to reveal the information about its own cost to competing firms. In terms of “Merger Approval”, we compare consumer welfare standard and total welfare standard under two different timings of regulation intervention (ex ante or ex post enforcement). Since prudent Competition Authorities (using ex ante intervention) should take the restrictive policy, our framework illustrates why US Horizontal Merger Guidelines and EC Merger Regulation are biased in favor of the consumers’ interests.*

1.1 Introduction

Horizontal mergers are typically studied in a deterministic environment (Salant et al., 1983; Perry and Porter, 1985; Deneckere and Davidson, 1985). Nevertheless, mergers create uncertainty, one source of such uncertainty is the production costs of participant firms. For instance, mergers create the uncertainty for employees because of the potential clashes of culture and management style, this uncertainty can lead to such dysfunctional outcomes as stress, job dissatisfaction, low trust in the organization, and increased intentions to leave the organization. These dysfunctions can, in turn, diminish productivity and increase the production cost (Morán and Panasian, 2005).

This chapter analyzes the incentive to merge and the welfare effects of mergers in (quantity-setting) uncertain markets where output decision-making process is sequential. This framework is related to two strands of the merger literature. The first strand typically focuses upon the relationship between sequentiality (leader and/or follower) and merger incentive in a context of deterministic markets. Levin (1990) shows that in the absence of uncertainty, the private incentive to merge is higher and antagonism between the private and the collective advantage of the merger disappears, when a merged firm changes its behavior from a Cournot-Nash player to a Stackelberg leader player. In a game where asymmetric roles among the firms in the pre-merger situation (Stackelberg leader and follower compete in homogeneous good market) are introduced, mergers can also improve welfare and boost profits. For instance, when two followers decide to merge and when the newly merged entity behaves as a leader on the product market, the social welfare and merging firms' profits increase even without cost savings following the merger (Daughety, 1990). In Stackelberg markets with n rival firms and linear costs, two leaders rarely have an incentive to merge, nor do two followers when the new entity stays in the same category (Huck, Konrad and Mueller, 2001).

On the other hand, in the presence of uncertainty, to the best of our knowledge, all theoretical analyses are based on the key assumption that output (or price) decision-making process is simultaneous (Cournot or Bertrand). Amir et al. (2009)

highlight the fact that the scope of profitable merger enlarges with uncertainty. The uncertain efficiency gains affect the *ex ante* beliefs on the merged firm's cost by outsiders and elicit the competitive advantage to the merged firm from strategic aspects. Some authors investigate how cost uncertainty affects the incentives to merge, and they show that the incentives to merge depend on the information structure (Choné and Linnemer, 2008; Zhou, 2008a and 2008b). Banal-Estanol (2007) also investigates merger incentive under cost uncertainty. He concludes that uncertainty always enhances merger incentives if the signals are privately observed. The above-mentioned papers focus on the cost (or efficiency gains) uncertainty. There are also some frameworks which deal with the issue of merger under demand uncertainty, for instance, Gal-Or (1988) finds that demand uncertainty and asymmetric information may hinder mergers.

In the current chapter, we turn our attention to cost uncertainty on merger with sequential output decisions in order to fulfill the gap of merger issue. The key assumption is that all firms face uncertainty as to the efficiency gains, in terms of variable costs that the merged firm could achieve, within the "Private incentive to merge" decision analysis (*Merger* phase); once the merger is consummated, insider *first-to-knows* its own actual cost, outsider-followers can perfectly observe the output level of merged firm (if insider behaving as leader) and infer the exact value of merged firm's cost within the "Profitability of merger" (*Post Merger* phase). This information structure is different from the one proposed by Amir et al. (2009) where after merger no outsider is informed about the merged firm's cost. The difference stems from the sequentiality of output decision. For instance, if the merged firm behaves as a leader, which makes the production decision firstly, the outsider-follower firms observe the production level of the insider and infer the actual cost of the insider. This design permits us to restudy the merger in the context of close relationship between the distribution of roles and the information structure. Concretely, the behavior of merged entity can alter the outsider firms' information configuration: leader strategy chosen by insider generates the asymmetric information amongst non-merged firms (the outsider-follower is aware of insider's cost, while the outsider-leader is not informed about it) and there will be the symmetric information amongst outsiders when insider behaves as a follower.

In order to capture the impact of role distribution and information configuration, we take into account all possible two-firm mergers, such as merger between leaders (or followers), merger between leader and follower, and merger between followers resulting in merged leader firm¹.

Before the merger consummation, firms do not learn the actual cost of the merged entity, the incentive to merge for participants grows following the enlargement of variance. Till the extent of variance exceeds a certain threshold, the expected profit of the merged firm becomes larger than the sum of the pre-merger (participant) firms' profits, and these firms facing cost uncertainty choose to merge. This finding highlights that even if there is neither efficiency gains nor informational advantage for merging firm, the cost uncertainty is able to induce the firms to merge. The relationship between cost uncertainty and merger incentives is also investigated by Banal-Estanol (2007) and Zhou (2008a). The former finds that cost uncertainty always enhances the incentives to merge and argues that the extra incentive is driven by information sharing. The latter shows that the extra merger incentives are reinforced by production rationalization. In our framework, the additional incentives are engendered by both role redistribution and lack of information.

From another perspective, the question of potential efficiency gains² related to horizontal mergers is widely discussed. According to Scherer: "*an impressive accumulation of evidence points to the conclusion that mergers seldom yield substantial cost savings, real or pecuniary*" (Scherer, 1980, p.546). Tichy (2002) observes that only 25% of mergers generate efficiency gains. In some studies, it has been also identified that firms involved in merger operations may register a decline in their market share (Mueller, 1985). Furthermore, Harrison (2010) finds that merging

¹The reason that we focus only on bilateral merger is explained by some illustrations in automotive domain, *e.g.* Daimler-Chrysler in 1998, Porsche-VW during 2004-2008, Chrysler-Fiat in 2009, *etc.* From the theoretical viewpoint, Zhou (2008a) demonstrates that two-firm mergers are far more frequent than three- or four-firm mergers.

²One of the common arguments for mergers is the "synergies", allowing the two companies to work more efficiently together than either would separately. Such synergies may result from the firms' combined ability to exploit economies of scale, eliminate duplicated functions, share managerial expertise, and raise larger amounts of capital.

hospitals have higher costs than non-merging hospitals. This lack of empirical precision concerning the effect of the merger on production costs justifies the model in which the production cost of the merged entity is altered due to the merger.

Accordingly, we consider that mergers not only create market power, but also yield efficiency gains (or losses) of *random* magnitude. The merged entity's cost information is private before the time of production, and the insider is able to signal its private information about the consequence of the merger through its market conduct. Since the firms outside of the merger (outsiders) are composed of leaders and followers, it is not only the merged firm (insider) that gets to recognize its cost, but also followers can actually observe the merged firm's cost because of the second mover in case of the newly merged firm behaving as a leader. Meanwhile, each outsider-leader firm chooses one output level to maximize its *ex ante* expected profits for lack of information. Thus, when the merged firm behaves as a leader, there is the asymmetric information between outsider-leader and outsider-follower firms; when the merged firm plays the follower role, the gap of information among outsiders disappears, because all outsiders are uninformed about the real cost of merged entity. We analyze the profitability of merger in context of informational asymmetry. It is shown that the two-follower merger aiming to a leader strategy occurs more likely than the one satisfying *statu quo*. Furthermore, the merged firm has interests to pool the private signals to outsiders, in the absence of role redistribution. By contrast, in the presence of role redistribution, the concealment is more profitable from the viewpoint of insider.

Concerning "Merger Approval", we firstly study the case where Competition Authorities adopt the *ex ante* enforcement, in other words, they decide whether to approve or refuse the merger proposal without knowing³ the actual cost of potentially merged entity. Under this circumstance, the merger between leaders always enhances welfare, as long as the participants have incentives to merge. This generates the unanimity of private and collective incentives, and it provides support for *laissez-faire* policy. Furthermore, enforcement practice in most countries (in-

³See US Merger Guidelines Section 4. Merging parties, arguably, know more about potential efficiency gains than Competition Authorities. Firms have strong incentives to dissemble about efficiency.

cluding the US and the EU) is closest to a consumer welfare standard⁴. Thus, we carry on a separate analysis of consumer surplus in order to gain some insight into the relationship between distinct criteria of Competition Authorities and merger issue within sequential quantity-setting game.

Without loss of generality, the *ex post* policy intervention is also used by Competition Authorities to judge the implemented merger. The Synopsys decision⁵ and the Muris speech⁶ along with the recent FTC (Federal Trade Commission) enforcement actions against several consummated mergers⁷ all suggest that although the HSR (Hart Scott Rodino⁸) statute makes *ex ante* merger enforcement possible, it does not proscribe the government from choosing *ex post*⁹ enforcement if the

⁴In merger control, the emphasis is now firmly on consumer surplus. It is worth reflecting on the rationale put forward in support of a consumer welfare policy standard in these areas (as opposed to a total welfare standard). In principle, economists advocate a total welfare standard that encompasses a balancing of rents to producers and consumers. Nevertheless, there are several arguments in support of entrusting a competition agency with a consumer surplus standard. These are based on the following considerations: (1) informational advantages, (2) merger selection bias, and (3) lobbying activities. In addition a consumer standard is considered to be easier to implement.

⁵The Federal Trade Commission's unanimous decision not to challenge in advance Synopsys, Inc. acquisition of Avant! Corporation in 2002 provides a good illustration of why the FTC has partially moved away from the dominant paradigm of *ex ante* merger enforcement. As with almost any merger investigation, the FTC had to determine whether, in the words of Commissioner Anthony, "efficiencies will be sufficient to outweigh any potential harm to competition." Commissioner Anthony emphasized that there was a great deal of uncertainty regarding the answer in this particular case. Thus, while all Commissioners voted to close the investigation, Anthony and two other Commissioners also issued statements suggesting that the Commission should carefully monitor the market to consider a later, *ex post*, challenge to the merger. See more detailed in Statement of Commissioner Sheila F. Anthony and Commissioner Thomas B. Leary, Synopsys Inc./Avant! Corporation, FTC File No.021-0049.

⁶Former Federal Trade Commission (FTC) Chairman Timothy Muris, however, has suggested a renewed interest in government enforcement of mergers after the fact: "If you have clients that are concerned with a transaction, let us know - whether or not it has been consummated. We are quite prepared to go after consummated mergers or mergers that are too small to require an HSR filing." See Prepared Remarks of Timothy J. Muris, Antitrust Enforcement at the Federal Trade Commission: In a Word - Continuity, before American Bar Association Antitrust Section Annual Meeting, Chicago, IL, August 7, 2001.

⁷See Compton and Sher (2003) and Leibeskind (2004) for a discussion of these enforcement actions

⁸Prior to the passage of the Hart Scott Rodino (HSR) Act in 1976, the U.S. government could only challenge mergers after they had been consummated.

⁹In some theoretical papers, the distinction between *ex ante* and *ex post* enforcement has been emphasized, such as Besanko and Spulber (1989), Berges-Sennou et al. (2001), Pénard and Souam (2002a). The *ex post* enforcement of competition authorities involves a comparison

conditions suggest it is likely to be superior. According to Ottaviani and Wickelgren (2011), the Competition Authorities can employ a “wait and see” approach by letting the merger go through in order to have more accurate information about it. In particular, as Leibeskind (2004) has noted, because antitrust jurisprudence and recent industrial organization scholarship have both moved away from strong structural presumptions about what makes a merger anti-competitive, there is a stronger need for solid evidence of anti-competitive effects. Because these can be hard to prove *ex ante*, this explains the recent renewed interest in *ex post* merger enforcement and why to introduce the *ex post* enforcement in this framework.

By studying two alternative criteria under two different policy intervention timings¹⁰, we find that the timing of policy intervention has important implication to the choice between the two welfare standards: the consumer welfare standard is more *rigorous* than the aggregate welfare standard in case of *ex ante* enforcement, while the consumer welfare standard is more *lenient* under *ex post* enforcement. Since prudent Competition Authorities (using *ex ante* intervention) should take the *restrictive* policy, our framework illustrates the reason why US Horizontal Merger Guidelines and EC Merger Regulation are biased in favor of the consumers’ interests.

The remainder of the chapter is organized as follows. Section 1.2 presents the model and specifies the sub-game perfect equilibria for different types of mergers within uncertain markets. Section 1.3 analyzes the “Private incentive to merge” and the “Profitability of merger”. Section 1.4 investigates the welfare implications of mergers and studies the relationship between private intention and collective incentive, this section is also devoted to some research about Competition Authorities’ distinct criteria (aggregate welfare standard or consumer welfare standard). Section 1.5 extends the model to allow Competition Authorities to adopt the *ex post* enforcement. Finally, section 1.6 discusses our main findings and concludes.

between the outcome of antitrust intervention and a counterfactual that describes what would have happened (or not happened) in its absence. It allows for an assessment of the benefits of enforcement and hence, when related to the cost of enforcement.

¹⁰See *ex ante* safety regulation and *ex post* tort liability in Shavell (1984) and Kolstad et al.(1990); *ex ante* versus *ex post* regulation of bank capital in Daripa and Varotto (2005); *ex ante* and *ex post* merger control in Ottaviani and Wickelgren (2008).

The detail and some complicated expressions are in the Appendix.

1.2 Model

The timing of this game is summarized in the sketch map (Figure 1.1) which shows both decision structure and information structure in a time axis. Benchmark competition is modelled as a standard Stackelberg game with complete information to all active firms. The merger may generate either efficiency gains or losses, and there is some uncertainty on what will be the exact value of the insider’s marginal cost. Consequently, the merger not only gives rise to the productivity shock in newly merged entity at the time of merger, but also introduces a modification in the information structure of players, once the merger is implemented.

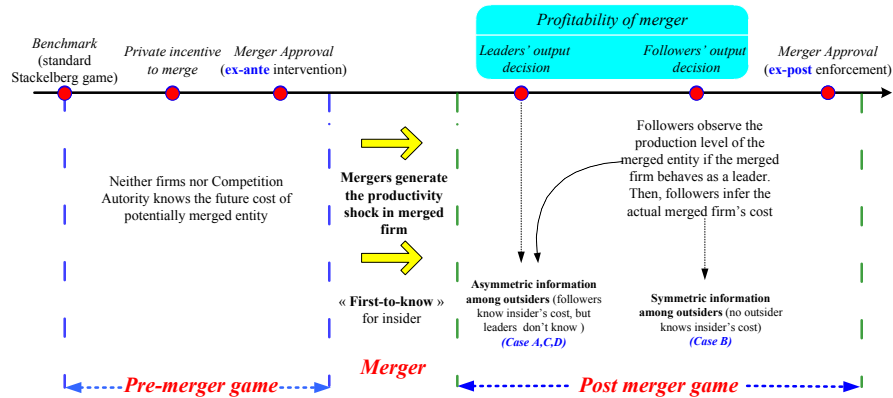


Figure 1.1. Game structure

At the point of “Private incentive to merge”, all firms (including the merging firms) in industry face uncertainty as to the efficiency gains, in terms of variable

marginal cost, that the merged firm could achieve. Thus, any merging firms must decide whether or not to merge without knowing the true cost of the potentially merged firm in future.

Without loss of generality, we assume that there are two alternative timings of antitrust intervention: the one is *ex ante* intervention, Competition Authorities decide whether the merger in question is approved, facing cost uncertainty; the other is *ex post* enforcement, the insider recognizes its own production cost level after merger consummation and signals its private information through its market conduct, thus, Competition Authorities get to obtain the information¹¹ about the production cost of insider, the advantage of *post-hoc* review is that Competition Authorities can focus more on history than on predictions.

Once mergers are authorized, we turn to the *post merger* game where insider *first-to-knows* its own exact cost, and part of outsiders (outsider-followers) could be aware of the actual cost of insider during the “Profitability of merger”. This information structure is different from the one proposed by Amir et al. (2009) where after merger none of outsiders are informed about the merged firm’s cost. The difference of the information structures stems from the sequentiality of output decision. For instance, if the merged firm behaves as a leader, which makes the production decision firstly, the outsider-follower firms observe the production level of insider and infer the actual productivity (cost) level of insider. This novel ingredient permits us to restudy the merger in the presence of the distribution of roles and the different information configurations. Concretely, the strategic behavior of merged entity can alter the outsider firms’ information configuration: leader strategy chosen by insider generates the asymmetric information amongst non-merged firms (because the outsider-follower firms are aware of insider’s cost, but the outsider-leader firms are not informed about it.) and there will be the symmetric information amongst outsiders when insider behaves as a follower. In order to capture the impact of the roles’ distribution in the *pre-merger* situation

¹¹According to timing, CAs with *ex post* enforcement interfere after the “Output decision”, it is logical that CAs are aware of the actual production cost of insider. We suppose that there is no cost for acquiring the information. For instance, if the insider behaves as a leader, followers and CAs have the complete information on actual production cost of merged entity at no cost.

and the impact of informational structure in the *post merger* situation, we examine four alternative scenarios: a merger between two leaders (case A), a merger between two followers (case B), a merger between two followers resulting in a newly merged leader (case C) and a merger between one leader and one follower resulting in a newly merged leader (case D).

The benchmark situation

We consider an industry composed of n initially active firms producing homogenous products, who compete by setting quantity schedules. In the first stage, $m < n$ firms act as Stackelberg leaders and independently decide on their individual supply. In the second stage, $n - m$ Stackelberg followers decide upon their quantity after learning about the total quantity supplied by the leaders. Initially, we assume $m > 2$ and $n - m > 2$, the strict inequalities ensure that in every case the outsiders gather both leader and follower in the *post merger* situation.¹² All firms face the same constant average cost normalized to c . The market price is determined by the linear inverse demand curve $p = a - Q$ where $a > c$. The aggregate industry output is given by $Q = Q^l + Q^f$ with $Q^l = \sum_{i=1}^m q_i^l$ and $Q^f = \sum_{i=m+1}^n q_i^f$, q_i denotes the firm i 's individual quantity. The superscript “ l ” stands for a leader and “ f ” represents a follower.

The equilibria are obtained by backward induction. At the second (follower output decision) stage, each follower maximizes its profit (π_i^f) considering as given the production level of leader (Q^l). The best response function (q_i^f) of a follower firm results from:

$$\max_{q_i^f} \pi_i^f = (a - Q^l - Q^f - c)q_i^f$$

At the first (leader output decision) stage, a leader selects its profit-maximizing

¹²The particular cases: both $m = 0$ and $m = n$ correspond to a Cournot industry, the firms are in the simultaneous game. The Stackelberg and Cournot models are similar because in both competition is on quantity. However, as seen, the first move gives the leader in Stackelberg a crucial advantage. There is also the important assumption of perfect information in the Stackelberg game: the follower must observe the quantity chosen by the leader, otherwise the game reduces to Cournot.

output (q_i^l) anticipating the best response function of each follower:

$$\max_{q_i^l} \pi_i^l = [a - c - Q^l - Q^f(Q^l)] q_i^l$$

In the benchmark situation, the corresponding individual outputs and profits are:

$$q_i^l(m) = \frac{a - c}{m + 1} \quad \pi^l(n, m) = \frac{(a - c)^2}{(m + 1)^2(n - m + 1)}$$

$$q_i^f(n, m) = \frac{a - c}{(n - m + 1)(m + 1)} = \frac{1}{n - m + 1} q_i^l$$

$$\pi^f(n, m) = \frac{(a - c)^2}{(m + 1)^2(n - m + 1)^2} = \frac{1}{n - m + 1} \pi^l$$

Obviously, the distribution of roles among firms exhibits the first mover advantage¹³: each leader benefits from higher market share and earns higher profit in benchmark game.

The different merger scenarios

In this subsection, we focus upon a bilateral (two-firm) merger. When two firms make the decision whether to merge, all firms including the merging firms in the market are uncertain over the marginal cost of the newly merged entity. Thus, any two merging firms must decide whether or not to merge without knowing the actual cost of the merged firm in future. We suppose that the expected marginal cost of the merged firm is equal to the non-merged firm's cost “ c ” which is the same as the benchmark firm's one¹⁴. The exact value of newly merged entity's

¹³The leader's profit under the sequential-game equilibrium will be higher than under Cournot equilibrium. Since follower firm reacts in a “Nash fashion”, leader firm could just choose to produce the Cournot output level. In this case, leader firm would earn exactly the Cournot profit. However, since in the sequential game leader firm chooses to produce a different output level, it must be increasing its profit compared with the Cournot profit level. The kind of reasoning is called a *revealed profitability* argument.

¹⁴This assumption allows us to focus on the effect of uncertainty on mergers even without any uncertain efficiency gains.

cost “ c_i ” is uncertain, it could be either higher or lower than this critical value c . Hence, we assume that $a > \max\{c, c_i\}$ and the variance of this uncertain cost c_i is independently drawn from an identical distribution with $Var(c_i) = \sigma^2$. The variance σ^2 represents the degree of the uncertainty and captures marginal cost fluctuation. The merging firms can generate efficiency gains if $c_i - c < 0$. This situation corresponds to the usual argument which puts forward to the increase in productive efficiency generated by the merger itself. Conversely, when $c_i - c > 0$ the merger is assumed to cause efficiency losses (*i.e.* due to the clash of company culture).

Case A: Merger between two leaders

In this case, the industry is composed of $m - 1$ leaders but still $n - m$ followers since the newly merged entity behaves as a leader. Consider $q_I^{l,A}$ as the merged firm’s quantity and $q_O^{l,A}$ as outsider-leader firm’s output and $q_O^{f,A}$ as outsider-follower’s output. From the standpoint of information structure, since insider *first-to-knows* its production cost (or productivity), its output level will depend on the actual cost (c_i), namely $q_I^{l,A}(c_i)$; outsider-followers observe the output level of insider and then perfectly infer the merged entity’s cost, accordingly $q_O^{f,A}(c_i)$; as all leaders simultaneously decide the quantity level, outsider-leaders have no chance to observe the insider production, consequently, the outsider-leaders regard c as the insider’s productivity, we have $q_O^{l,A}(c)$.

By backward induction, we begin with the follower production stage. The optimizing question is

$$\max_{q_O^{f,A}} \pi_O^{f,A} = (p^A - c)q_O^{f,A} = [a - c - Q_O^{-f,A} - q_O^{f,A} - Q_O^{l,A}(c) - q_I^{l,A}(c_i)]q_O^{f,A}$$

From the first-order-condition, we derive the best response function of followers (See detail in **Appendix A.1**):

$$(n - m + 1)q_O^{f,A} = a - c - Q_O^{l,A}(c) - q_I^{l,A}(c_i) \quad (1.1)$$

In the first (leader production) stage, outsider leaders are not aware of the

actual cost of insider, thereby, they consider the insider's cost as the expected value c and maximize the following profit function:

$$\max_{q_O^{l,A}} \pi_O^{l,A} = (p^A - c)q_O^{l,A} = [a - c - Q_O^{f,A} - Q_O^{-l,A}(c) - q_O^{l,A} - q_I^{l,A}(c)]q_O^{l,A}(c)$$

For the insider, since it knows the real cost c_i

$$\max_{q_I^{l,A}} \pi_I^{l,A} = (p^A - c_i)q_I^{l,A} = [a - c_i - Q_O^{l,A}(c) - Q_O^{f,A} - q_I^{l,A}(c_i)]q_I^{l,A}(c_i)$$

We then obtain the following expressions for the equilibrium output (See detail in **Appendix A.2**):

$$q_I^{l,A}(c_i) = \frac{2(a - c) - m(n - m + 1)(c_i - c)}{2m} \quad (1.2)$$

$$q_I^{l,A}(c) = \frac{(a - c)}{m}$$

$$q_O^{l,A}(c) = \frac{(a - c)}{m}$$

$$q_O^{f,A}(c_i) = \frac{2(a - c) + m(n - m + 1)(c_i - c)}{2m(n - m + 1)}$$

The aggregate quantity is expressed as

$$Q^A = q_I^{l,A}(c_i) + (m - 2)q_O^{l,A}(c) + (n - m)q_O^{f,A}(c_i)$$

Both the equilibrium profits and the expected equilibrium profits of firms are given as follows (See detail in **Appendix A.3**).

Insider:

$$\pi_I^{l,A} = \frac{[2(a - c) - m(n - m + 1)(c_i - c)]^2}{4m^2(n - m + 1)} \quad (1.3)$$

$$\mathbb{E}[\pi_I^{l,A}] = \frac{(a - c)^2}{m^2(n - m + 1)} + \frac{n - m + 1}{4}\sigma^2 \quad (1.4)$$

Since the marginal cost of outsiders is unchangeable and the merged entity

learns its own production cost after merger, the merged entity possesses complete information at the moment of “Production decision”. $\pi_I^{l,A}$ represents the exact value of merged firm’s profit which will be used to analyze the profitability of merger. In addition, the expected profit of merged firm is determined at the moment of “Private incentive to merge” where the actual cost of merged firm is concealed from all firms including merging parties, and this expected term is used to analyze the incentive to merge in the following section.

Outsider-leader:

$$\pi_O^{l,A} = \frac{(a - c)[2(a - c) + m(n - m + 1)(c_i - c)]}{2m^2(n - m + 1)} \quad (1.5)$$

$$\mathbb{E}[\pi_O^{l,A}] = \frac{(a - c)^2}{m^2(n - m + 1)} \quad (1.6)$$

Outsider-leader firms commit to quantities before the uncertainty is resolved, therefore, they possess *zero information* on merged entity’s cost, and only the expected value of the cost is relevant to them. A larger uncertainty, in the sense of an increased variance in the cost distribution with the same expected value, will not change the profit of outsider-leader firms. Consequently, uncertainty has no effect on them, and each outsider-leader’s expected profit is the same as when merged firm’s cost is deterministic ($c_i = c$).

Outsider-follower:

$$\pi_O^{f,A} = \frac{[2(a - c) + m(n - m + 1)(c_i - c)]^2}{4m^2(n - m + 1)^2} \quad (1.7)$$

$$\mathbb{E}[\pi_O^{f,A}] = \frac{(a - c)^2}{m^2(n - m + 1)^2} + \frac{1}{4}\sigma^2 \quad (1.8)$$

It is worthwhile to note that, since both the merged firm and the outsider-follower firms know the exact marginal cost of merged entity, in addition, outsider-leader firms recognize no change in merged firm’s cost after merger, the asymmetric information about the merged entity’s cost not only does work in favor of the merged firm, but also is propitious to outsider-follower firms. This is because firms of both categories can adjust their production accordingly. In expected terms, the

sensibility of firms' gains to the uncertainty is not the same. The cost uncertainty effect affects more strongly the merged entity than the outsider (followers) group.

The consumer surplus (**CS**) and the social welfare (**W**) are easily found to be:

$$CS^A = \frac{\{2[1 - m(n - m + 1)](a - c) + m(n - m + 1)(c_i - c)\}^2}{8m^2(n - m + 1)^2} \quad (1.9)$$

$$W^A = CS^A + \pi_I^{l,A}(c_i) + (m - 2)\pi_O^{l,A}(c) + (n - m)\pi_O^{f,A}(c_i) \quad (1.10)$$

By simple calculation, we obtain the following expected values of CS and W .

$$\mathbb{E}[CS^A] = \frac{(a - c)^2[1 - m(n - m + 1)]^2}{2m^2(n - m + 1)^2} + \frac{1}{8}\sigma^2 \quad (1.11)$$

$$\begin{aligned} \mathbb{E}[W^A] &= \mathbb{E}[CS^A] + \mathbb{E}[\pi_I^{l,A}] + (m - 2)\mathbb{E}[\pi_O^{l,A}] + (n - m)\mathbb{E}[\pi_O^{f,A}] \quad (1.12) \\ &= \frac{(a - c)^2}{2} \left[\frac{m^2(n - m + 1)^2 - 1}{m^2(n - m + 1)^2} \right] + \left(\frac{n - m}{2} + \frac{3}{8} \right) \sigma^2 \end{aligned}$$

Note that both consumer surplus and social welfare are increasing functions with respect to the variance σ^2 . Concretely, we have $\frac{\partial \mathbb{E}[CS^A]}{\partial \sigma^2} = \frac{1}{8}$ and $\frac{\partial \mathbb{E}[W^A]}{\partial \sigma^2} = \frac{n - m}{2} + \frac{3}{8}$. The extent of the uncertainty effect on welfare evidently depends on the role distribution. The more leader firms, the lower impact of uncertainty on welfare.

Case B: Merger between two followers

In this case, we consider that two followers take part in the merger. The distribution of roles in the industry is assumed not to be altered by the merger decision in the way that merged entity behaves as a follower. The industry contains $n - 1$ firms with m leaders. From the viewpoint of informational structure, neither outsider-leader firms nor outsider-follower firms can infer the exact marginal cost of the merged firm, because this new second-mover entity and the non-merged followers simultaneously make the output decisions. Therefore, there is the informational

symmetry between the outsider-leaders and the outsider-followers which are both unaware of the merged firm's actual cost. The relevant equilibrium values are shown in Table 1.1. (See brief demonstration in **Appendix A.4**)

Table 1.1. Equilibrium values in case B

Equilibrium	Case B	
	Actual terms ^a	Expected terms ^b
Output	$q_I^{f,B}(c_i) = \frac{2(a-c)-(m+1)(n-m)(c_i-c)}{2(m+1)(n-m)}$ $q_O^{i,B}(c) = \frac{(a-c)}{(m+1)}$ $q_O^{f,B}(c) = \frac{(a-c)}{(m+1)(n-m)}$	$q_I^{f,B}(c) = \frac{(a-c)}{(m+1)(n-m)}$
Profit	$\pi_I^{f,B} = \frac{[2(a-c)-(m+1)(n-m)(c_i-c)]^2}{4(m+1)^2(n-m)^2}$ $\pi_O^{i,B} = \frac{(a-c)[2(a-c)-(m+1)(n-m)(2-c-c_i)]}{2(m+1)^2(n-m)}$ $\pi_O^{f,B} = \frac{(a-c)[2(a-c)-(m+1)(n-m)(2-c-c_i)]}{2(m+1)^2(n-m)^2}$	$\mathbb{E}[\pi_I^{f,B}] = \frac{(a-c)^2}{(m+1)^2(n-m)^2} + \frac{1}{4}\sigma^2$ $\mathbb{E}[\pi_O^{i,B}] = \frac{(a-c)}{m+1}$ $\mathbb{E}[\pi_O^{f,B}] = \frac{(a-c)^2}{(m+1)^2(n-m)^2} - \frac{a-c}{(m+1)(n-m)}$
Consumer surplus	$CS^B = \frac{[2(a-c)][(m+1)(n-m)-1-(m+1)(n-m)(c_i-c)]^2}{8(m+1)^2(n-m)^2}$	$\mathbb{E}[CS^B] = \frac{(a-c)^2[(m+1)(n-m)-1]^2}{2(m+1)^2(n-m)^2} + \frac{1}{8}\sigma^2$
Social welfare	$W^B = CS^B + \pi_I^{f,B} + m\pi_O^{i,B} + (n-m-2)\pi_O^{f,B}$	$\mathbb{E}[W^B] = \mathbb{E}[CS^B] + \mathbb{E}[\pi_I^{f,B}] + m\mathbb{E}[\pi_O^{i,B}] + (n-m-2)\mathbb{E}[\pi_O^{f,B}]$ $\frac{\partial \mathbb{E}[W^B]}{\partial \sigma^2} = \frac{3}{8}$

^a **Actual terms** refer to the post merger game where the insider learns its own cost level. The merger profitability and *ex post* merger assessment are analyzed based on these values.

^b **Expected terms** refer to the pre-merger game where the (merger) participants do not know the future productivity level. The private incentive to merge and *ex ante* enforcement merger control are studied by means of these expected values.

Case C: Merger between two followers resulting in a leader

Consider a special type of merger wherein two followers merge and result in a firm behaving as leader. As a result, there are $m + 1$ leaders and in contrast $n - m - 2$ followers. This case was examined by Daughety (1990) who found that the horizontal merger was potentially profitable for the merged firm and this merger might be advantageous from the viewpoint of social welfare in the absence of cost variation. We restudy this scenario by introducing two elements: cost uncertainty and information structure, to proceed the in-depth analysis. Of course, the outcome found by Daughety (1990) corresponds to our result in the extreme situation where there is no uncertainty and the information is perfect and complete. The equilibrium values are displayed in Table 1.2.

Table 1.2. Equilibrium values in case C

Equilibrium	Case C	
	Actual terms	Expected terms
Output	$q_I^{I,C}(c_i) = \frac{2(a-c)-(m+2)(n-m-1)(c_i-c)}{2(m+2)}$ $q_O^{I,C}(c) = \frac{a-c}{m+2}$ $q_O^{f,C}(c_i) = \frac{2a-c[(m+2)(n-m)-m]+(m+2)(n-m-1)c_i}{2(m+2)(n-m-1)}$	$q_I^{I,C}(c) = \frac{(a-c)}{(m+2)}$
Profit	$\pi_I^{I,C} = \frac{[2(a-c)-(m+2)(n-m-1)(c_i-c)]^2}{4(m+2)^2(n-m-1)}$ $\pi_O^{I,C} = \frac{(a-c)[2(a-c)+(m+2)(n-m-1)(c_i-c)]}{2(m+2)^2(n-m-1)}$ $\pi_O^{f,C} = \frac{[2(a-c)+(m+2)(n-m-1)(c_i-c)]^2}{4(m+2)^2(n-m-1)}$	$\mathbb{E}[\pi_I^{I,C}] = \frac{(a-c)^2}{(m+2)^2(n-m-1)} + \frac{(n-m-1)}{4}\sigma^2$ $\mathbb{E}[\pi_O^{I,C}] = \frac{(a-c)^2}{(m+2)^2(n-m-1)}$ $\mathbb{E}[\pi_O^{f,C}] = \frac{(a-c)^2}{(m+2)^2(n-m-1)^2} + \frac{1}{4}\sigma^2$
Consumer surplus	$CS^C = \frac{\{2(a-c)[(m+2)(n-m-1)-1]-(m+2)(n-m-1)(c_i-c)\}^2}{8(m+2)^2(n-m-1)}$	$\mathbb{E}[CS^C] = \frac{(a-c)^2[(m+2)(n-m-1)-1]^2}{2(m+2)^2(n-m-1)^2} + \frac{1}{8}\sigma^2$
Social welfare	$W^C = CS^C + \pi_I^{I,C} + m\pi_O^{I,C} + (n-m-2)\pi_O^{f,C}$	$\mathbb{E}[W^C] = \mathbb{E}[CS^C] + \mathbb{E}[\pi_I^{I,C}] + m\mathbb{E}[\pi_O^{I,C}]$ $+ (n-m-2)\mathbb{E}[\pi_O^{f,C}]$ $\frac{\partial \mathbb{E}[W^C]}{\partial \sigma^2} = \frac{n-m}{2} - \frac{5}{8}$

Case D: Merger between one leader and one follower

Finally, we focus on the merger between one leader and one follower (the merged entity behaves as a leader). The number of leaders is the same as in the case B, and the number of leaders outside of merger equals to $m - 1$. This case without taking into account the issue of information sharing and uncertainty, was studied by Huck, Konard and Muller (2001), who were the first to observe that the merger between two firms from different categories increased the joint profits of firms. They compared the profitability of two-follower merger with that of leader-follower merger, and showed that mergers between a leader and a follower were unambiguously profitable. We derive the same outcome, if we suppose the merged firm's cost is unaltered and equals to c . The equilibrium values are shown in Table 1.3.

Table 1.3. Equilibrium values in case D

Equilibrium	Case D	
	Actual terms	Expected terms
Output	$q_I^{I,D}(c_i) = \frac{2(a-c)-(m+1)(n-m)(c_i-c)}{2(m+1)}$ $q_O^{I,D}(c) = \frac{a-c}{m+1}$ $q_O^{f,D}(c_i) = \frac{2(a-c)+(m+1)(n-m)(c_i-c)}{2(m+1)(n-m)}$	$q_I^{I,D}(c) = \frac{(a-c)}{(m+1)}$
Profit	$\pi_I^{I,D} = \frac{[2(a-c)-(m+1)(n-m)(c_i-c)]^2}{4(m+1)^2(n-m)}$ $\pi_O^{I,D} = \frac{(a-c)[2(a-c)+(m+1)(n-m)(c_i-c)]}{2(m+1)^2(n-m)}$ $\pi_O^{f,D} = \frac{[2(a-c)+(m+1)(n-m)(c_i-c)]^2}{4(m+1)^2(n-m)}$	$\mathbb{E}[\pi_I^{I,D}] = \frac{(a-c)^2}{(m+1)^2(n-m)} + \frac{n-m}{4}\sigma^2$ $\mathbb{E}[\pi_O^{I,D}] = \frac{(a-c)^2}{(m+1)^2(n-m)}$ $\mathbb{E}[\pi_O^{f,D}] = \frac{(a-c)^2}{(m+1)^2(n-m)^2} + \frac{1}{4}\sigma^2$
Consumer surplus	$CS^D = \frac{\{2(a-c)[(m+1)(n-m)-1]-(m+1)(n-m)(c_i-c)\}^2}{8(m+1)^2(n-m)^2}$	$\mathbb{E}[CS^D] = \frac{(a-c)^2[(m+1)(n-m)-1]^2}{2(m+1)^2(n-m)^2} + \frac{1}{8}\sigma^2$
Social welfare	$W^D = CS^D + \pi_I^{I,D} + (m-1)\pi_O^{I,D} + (n-m-1)\pi_O^{f,D}$	$\mathbb{E}[W^D] = \mathbb{E}[CS^D] + \mathbb{E}[\pi_I^{I,D}] + (m-1)\mathbb{E}[\pi_O^{I,D}] + (n-m-1)\mathbb{E}[\pi_O^{f,D}]$ $\frac{\partial \mathbb{E}[W^D]}{\partial \sigma^2} = \frac{n-m}{2} - \frac{1}{8}$

It is worth noting that the merged firm's profit, the levels of consumer surplus and social welfare (prior to the merger consummation) are increasing functions with respect to the variance. Thus, the merged firm's expected profit and the expected surpluses grow, as the uncertainty increases. By comparing the four aforementioned cases, we have the following remarks:

Remark 1. *The cost uncertainty has the strongest impact on the merged firm's expected profit when this entity is composed of two leaders, by contraries, the weakest effect on expected profit when two followers merge without role redistribution. More precisely, $\frac{\partial \mathbb{E}[\pi_I^A]}{\partial \sigma^2} > \frac{\partial \mathbb{E}[\pi_I^D]}{\partial \sigma^2} > \frac{\partial \mathbb{E}[\pi_I^C]}{\partial \sigma^2} > \frac{\partial \mathbb{E}[\pi_I^B]}{\partial \sigma^2}$. In terms of social welfare, the same ranking is found $\frac{\partial \mathbb{E}[W^A]}{\partial \sigma^2} > \frac{\partial \mathbb{E}[W^D]}{\partial \sigma^2} > \frac{\partial \mathbb{E}[W^C]}{\partial \sigma^2} > \frac{\partial \mathbb{E}[W^B]}{\partial \sigma^2}$. Furthermore, the intensity of uncertainty impact on merged firm's profit and on the social welfare depends upon the distribution of roles (n, m) except for case B.*

In cases A, C and D, the newly merged firm behaves as a leader, there is always asymmetric information between outsider-leaders and outsider-followers. The greater the number of followers $(n - m)$ in pre-merger market, the larger the intensity of uncertainty (on merged firm's profit and welfare). By contrast, when there is symmetric information between outsiders, the extent of uncertainty effect on merged firm's profit and on welfare are constant, irrespective of the number of followers.

For outsider-follower firms, the extent of the cost uncertainty will be the same, except for case B. Namely,

$$\frac{\partial \mathbb{E}[\pi_O^{f,A}]}{\partial \sigma^2} = \frac{\partial \mathbb{E}[\pi_O^{f,C}]}{\partial \sigma^2} = \frac{\partial \mathbb{E}[\pi_O^{f,D}]}{\partial \sigma^2} = \frac{1}{4}$$

Remark 2. *In all cases, welfare is more sensitive to the cost uncertainty compared to consumer surplus. Concretely, $\frac{\partial \mathbb{E}(W^i)}{\partial \sigma^2} > \frac{\partial \mathbb{E}(\pi_I^{j,i})}{\partial \sigma^2} > \frac{\partial \mathbb{E}(CS^i)}{\partial \sigma^2}$ ($i = \{A, B, C, D\}$ and $j = \{l, f\}$)*

In the following section, we provide a detailed account of the consequences of the merger on profits. By dealing with the effects of uncertainty, information structure and role redistribution, we analyze the firms' incentives to merge and the

profitability of merger.

1.3 Merger analysis

The merger incentive is investigated in a situation where the merger creates the productivity shock and all firms in industry therefore are uncertain about the merged firm's cost. We examine the private incentive to merge which results from the comparison between the *ex ante* expected profit of the merged firm and the sum of merging parties' profits in benchmark. This allows us to derive the conditions under which firms have incentives to merge without recognizing the future real cost of merged entity.

The focus of the study shifts to how asymmetric information affects the profitability of merger, and whether the merged firm has interests to reveal its private information to outsiders or to conceal its real cost from competing firms. The expressions of profit in different scenarios displayed in the previous section, enables us to study the profitability of merger which is determined by the difference of the sum of profits of merging firms in benchmark and the actual profit earned by the newly merged entity.

Private incentive to merge

Let $\Delta_{\mathbb{E}[\pi]}^i$ ($i = \{A, B, C, D\}$) represent the private incentive to merge. The firms have incentive to merge when $\Delta_{\mathbb{E}[\pi]}^i \geq 0$. The relationship between merger incentive and cost uncertainty under different scenarios is shown in Table 1.4.

Firstly, we demonstrate that the merging firms in scenarios C and D always have incentives to merge, irrespective of the cost uncertainty. This finding is consistent with the existing literature where the cost uncertainty is not taken into account. According to Daughety (1990), for instance, when two followers decide to merge and the newly merged entity behaves as a leader on the product market, the

Table 1.4. Merger incentive and cost uncertainty

Scenarios	$n \geq 6$ and $3 \leq m \leq n - 3$
Case A ($\Delta_{\mathbb{E}[\pi]}^A = \mathbb{E}[\pi_I^{l,A}] - 2\pi^l$)	$\Delta_{\mathbb{E}[\pi]}^A \geq 0$ when $\sigma^2 \geq \sigma_{\pi_A}^2$
Case B ($\Delta_{\mathbb{E}[\pi]}^B = \mathbb{E}[\pi_I^{f,B}] - 2\pi^f$)	$\Delta_{\mathbb{E}[\pi]}^B \geq 0$ when $\sigma^2 \geq \sigma_{\pi_B}^2$
Case C ($\Delta_{\mathbb{E}[\pi]}^C = \mathbb{E}[\pi_I^{l,C}] - 2\pi^f$)	$\Delta_{\mathbb{E}[\pi]}^C \geq 0$ always holds true
Case D ($\Delta_{\mathbb{E}[\pi]}^D = \mathbb{E}[\pi_I^{l,D}] - (\pi^l + \pi^f)$)	$\Delta_{\mathbb{E}[\pi]}^D \geq 0$ always holds true

With

$$\sigma_{\pi_A}^2 = \frac{4(a-c)^2(m^2 - 2m - 1)}{m^2(m+1)^2(n-m+1)^2} > 0$$

$$\sigma_{\pi_B}^2 = \frac{4(a-c)^2[(n-m)^2 - 2(n-m) - 1]}{(m+1)^2(n-m)^2(n-m+1)^2} > 0$$

firms have incentives to merge even without cost-saving (or efficiency gains). In addition, HKM (2001) show that the merger between one leader and one follower is profitable, in the absence of information issue and cost fluctuation.

Proposition 1. *If the cost uncertainty is sufficiently large, i.e., with $\sigma^2 \geq \sigma_{\pi_A}^2$ or $\sigma^2 \geq \sigma_{\pi_B}^2$, the merger without redistribution of roles can be accepted by merging parties. Moreover, if the number of leaders is greater than followers, the merger between leaders needs more uncertainty in order that these firms have incentives to merge; otherwise, the merger between followers requires more uncertainty.*

Proof:

$$\begin{cases} \sigma_{\pi_A}^2 > \sigma_{\pi_B}^2 > 0, & \text{when } \frac{n}{2} < m \leq n - 3; \\ \sigma_{\pi_B}^2 > \sigma_{\pi_A}^2 > 0, & \text{when } 3 \leq m < \frac{n}{2}. \quad \square \end{cases}$$

Proposition 1 implies that even if the expected cost is the same before and after merger, as the cost uncertainty grows larger, firms have more incentives to merge. Therefore, the expected profit of the merged firm grows following the enlargement

of variance. When the extent of the variance exceeds a certain threshold, such as $\sigma_{\pi_A}^2$ and $\sigma_{\pi_B}^2$, the expected profit of the merged firm becomes larger than the sum of the firm's profits in the benchmark case, and firms facing cost uncertainty choose to merge. This proposition highlights that even if there is neither efficiency gains nor informational advantage for merging firm, the cost uncertainty is able to induce the firms to merge.

The relationship between cost uncertainty and merger incentives is also investigated by Banal-Estanol (2007) and Zhou (2008a). The former finds that cost uncertainty always enhances the incentives to merge and argues that the extra incentive is driven by information sharing. The latter shows that the merger incentives are reinforced by production rationalization. In the current framework, the additional incentives are engendered by both role redistribution and informational asymmetry.

In the deterministic approach¹⁵, unless the market share is sufficiently large, most of the horizontal mergers are unprofitable. In proposition 1, as the variance of merged entity's cost is sufficiently close to zero, the firms without role redistribution have no incentive to merge, this outcome accords with the main result of SSR (1983). However, in our stochastic model, even when the firms have no incentive to merge in the traditional deterministic case, as the variance grows larger, the expected profit also increases because the gain of the optimal quantity adjustment enlarges, and the expected profit of merged firm can exceed the sum of profits of the pre-merger firms. Therefore, proposition 1 presents one of the explanations of the merger paradox.

¹⁵Salant et al.(1983) show that a merger is profitable only when more than 80% of the industry's firms participate in the merger. This is rather puzzling as it is at odds with the real-life observation of pervasive small-scale mergers. Later developments in merger studies have aimed at solving this puzzle. Scholars have suggested that the reactions form non-merged firms may be beneficial if the firms compete on price (Deneckere and Davidson, 1985) or they may be limited due to decreasing returns to scale (Perry and Porter, 1985) or product differentiation (Qiu and Zhou, 2006) or convex demand (Hennessy, 2000) or a disadvantageous position for non-merged firms (Daughety, 1990; Levin, 1990; Le Pape and Zhao, 2010). Some economists have suggested that mergers can also be achieved by cost-savings through elimination of duplicated fixed costs (Gaudet and Salant, 1992; Pepall et al., 2002) or transfer of superior technology (Farrell and Shapiro, 1990). All the papers mentioned analyze merger incentives in a deterministic environment with perfect information.

Profitability of merger

In this subsection, we consider the difference between the merged firm's exact cost (c_i) in case i ($i = \{A, B, C, D\}$) and expected firms' costs (c) as " δ^i ". The profitability of merger derives from the sign of the variation in actual profits (Δ_π^i). For instance, $\Delta_\pi^A = \pi_I^{l,A}(\delta^A, n, m) - 2\pi^l(n, m)$ in case A. The extent of the cost variation for merged firms interacts with the merger's profitability. We define δ_{sup}^A the threshold value of δ^A which separates profitable from unprofitable mergers. When $\delta^A < \delta_{sup}^A$ (respectively $\delta^A > \delta_{sup}^A$) we have $\Delta_\pi^A > 0$ (respectively $\Delta_\pi^A < 0$). In addition, in order to avoid boundary problems in which some firms are inactive, we also define δ_{inf}^A as the value of δ^A below which outsiders are ruled out of the market. It is given by the conditions : $q_O^{l,A} = 0$ and $q_O^{f,A} = 0$. Note that when we have $\delta_{inf}^A < \delta^A < \delta_{sup}^A$, the merger is profitable and two categories of outsiders remain on the market.

Incomplete information

Under incomplete information, the merged firm knows its own marginal cost, whereas not all outsider firms are aware of the actual cost of merged entity. In cases A, C and D, outsider-leader firms are uninformed about the exact value¹⁶ c_i , however, the timing of the game implies that outsider-follower firms are aware of c_i . In Table 1.5, we summarize the ranges of cost variation (δ^i) in different scenarios wherein the merger is profitable.

To ensure that none of outsider firms exit the market and the merger is profitable, the potential cost change in different scenarios should satisfy the condition that δ^i lies in the interval $(\delta_{inf}^i, \delta_{sup}^i]$. Note that there is no constraint on the exit of outsider in case B.

Remark 3. *By comparing δ_{sup}^i , we obtain:*

¹⁶In case B where two followers take part in the merger, all outsider firms are uninformed about the exact value c_i .

Table 1.5. Merger profitability and potential efficiency gains (or losses)

Scenarios	$n \geq 6$ and $3 \leq m \leq n - 3$
Case A ($\Delta_\pi^A = \pi_I^{l,A} - 2\pi^l$)	$\delta_{inf}^A < \delta \leq \delta_{sup}^A$
Case B ($\Delta_\pi^B = \pi_I^{f,B} - 2\pi^f$)	$\delta \leq \delta_{sup}^B$
Case C ($\Delta_\pi^C = \pi_I^{l,C} - 2\pi^f$)	$\delta_{inf}^C < \delta \leq \delta_{sup}^C$
Case D ($\Delta_\pi^D = \pi_I^{l,D} - (\pi^l + \pi^f)$)	$\delta_{inf}^D < \delta \leq \delta_{sup}^D$

With

$$\begin{aligned}
\delta_{inf}^A &= -\frac{2(a-c)}{m(n-m+1)} < 0 & \delta_{sup}^A &= \frac{2(a-c)}{m(n-m+1)} - 2\sqrt{2}\frac{a-c}{(n-m+1)(m+1)} < 0 \\
\delta_{inf}^C &= -\frac{2(a-c)}{(m+2)(n-m-1)} < 0 & \delta_{sup}^B &= -2\sqrt{2}\frac{(a-c)}{(m+1)(n-m+1)} + \frac{2(a-c)}{(n-m)(m+1)} < 0 \\
\delta_{inf}^D &= -\frac{2(a-c)}{(m+1)(n-m)} < 0 & \delta_{sup}^C &= -2\sqrt{2}\frac{(a-c)}{(m+1)(n-m-1)\sqrt{n-m-1}} + \frac{2(a-c)}{(m+2)(n-m-1)} > 0 \\
& & \delta_{sup}^D &= 2\left[\frac{a-c}{(m+1)(n-m)} - \frac{(a-c)}{(m+1)(n-m+1)}\sqrt{\frac{n-m+2}{n-m}}\right] > 0
\end{aligned}$$

- $\delta_{sup}^C > \delta_{sup}^D > 0 > \delta_{sup}^A > \delta_{sup}^B$ if $m \in [3, \frac{n}{2})$
- $\delta_{sup}^C > \delta_{sup}^D > 0 > \delta_{sup}^B > \delta_{sup}^A$ if $m \in (\frac{n}{2}, n-3]$

Since the values of upper bound δ_{sup} in case C and in case D are greater than zero, a merger with anticompetitive effects could also lead to efficiency losses. If the number of leaders is large enough (*i.e.*, $m \in (\frac{n}{2}, n-3]$), a profitable merger between two leaders requires more marginal cost reduction in comparison with a profitable merger between two followers. In other words, the conditions on efficiency gains, under which the two-follower merger is profitable, are less restrictive. By contrast, if there are more follower firms in pre-merger market, two-follower merger requires more efficiency gains to be profitable.

The higher δ_{sup}^i , the greater the allowed potential efficiency losses, the more likely mergers take place. Since the merger composed of two followers to form a leader (case C) generates potential efficiency losses higher than the merger between one leader and one follower (case D), to some extent that the merger in case C is

less restrictive and takes place more likely.

The ceiling of δ^i depends upon the redistribution of roles. For instance, If we compare the profitable merger in case B to the one in case C, it is found that the resulting leader is less restrictive than the resulting follower. Though the merger leads to efficiency losses, the resulting leader can be profitable due to the effect of role redistribution. It is clear that the two-follower merger aiming to a leader strategy takes place more likely than the one satisfying the *status quo*.

Incomplete Vs complete information

Under complete information¹⁷, the information about merged firm's real cost is no longer private, not only the merged firm is aware of its own marginal cost c_i , but also all outsider firms are informed about it. Using the deterministic case as a criterion, we study whether the merged firm has interests to reveal its own cost to competing firms¹⁸.

Consider $\hat{\pi}_I^{j,i}$ ($i = \{A, B, C, D\}$ and $j = \{l, f\}$) the merged firm's profit in the situation where there is complete and perfect information (see expressions of $\hat{\pi}_I^{j,i}$ in **Appendix A.5**). It will be interesting to compare the profit of the insider under incomplete information scenario to that under complete information situation.

Proposition 2. *Within the range of $\delta^i \in (\delta_{inf}^i, \delta_{sup}^i]$, the profit realized by the merged firm will be greater under complete information than under incomplete information, when there is no redistribution of roles for the merging parties. The opposite outcome will be obtained if there exists a role redistribution.*

Proof:

- $\pi_I^{l,A} < \hat{\pi}_I^{l,A}$ and $\pi_I^{f,B} < \hat{\pi}_I^{f,B}$

¹⁷The framework under complete information is studied in the working paper Le Pape and Zhao (2010).

¹⁸Under some circumstances (case A, C and D), outsider-follower firms can observe the insider's output level, and then infer the exact value of its marginal cost.

$$\bullet \pi_I^{l,C} > \hat{\pi}_I^{l,C} \quad \text{and} \quad \pi_I^{l,D} > \hat{\pi}_I^{l,D} \quad \square$$

The acquisition of market power is usually the first motive for horizontal mergers. The argument is that horizontal mergers increase market concentration, which, by increasing market power, increases profitability. In the absence of the redistribution of roles (cases A and B), the equilibrium price is higher under complete information than incomplete information, the higher price gives rise to higher market power, in addition, the merged firm produces more under complete information. Because of these two above-mentioned reasons, the merged firm will be more profitable under complete information, and it has interests to reveal information about its own cost to competing firms. This outcome is consistent with the well-known conclusion in the information sharing literature¹⁹, that, concentrates on a firm's incentives to share its private information with competing firms. In particular, it shows that firms competing in quantities are not willing to reveal their private information about market demand, but are willing to reveal their private information about production costs.

By contrast, in the presence of role redistribution (cases C and D), the strengthening of market power under incomplete information leads to more profitable merger compared to the one under complete information. This finding is in line with the conclusion of Zhou²⁰ who delineates that “firms are less likely to merge when they possess more information” (Zhou, 2008a, p.68).

The insider is the first firm that is informed about its own exact marginal cost, and consequently may enjoy the “first-to-know”. In Amir et al. (2009), the merged firm always benefits from “first-to-know”. In sharp contrast, within market where both leaders and followers exist, we demonstrate that “first-to-know disadvantage” could appear, in particular, when the merged firm has the same strategic behavior as *ex ante* merging firms. Under these circumstances, the informational asymme-

¹⁹There are some important contributions to this information sharing literature without merger issue, such as, Novshek and Sonnenschein (1982), Clark (1983), Vives (1984), Gal-Or (1985), Li (1985), Shapiro (1986) and Raith (1996).

²⁰The reason for Zhou (2008a) is that mergers are driven by production rationalization under cost uncertainty. When firms have more information, they are able to rationalize their production even without a merger, thus having less incentive to merge.

try created by merger is detrimental to the merged entity. This reinforces and illustrates the conjecture of Gal-or²¹, that “the merger may impose an informational disadvantage on each firm that colludes” (Gal-or, 1988, p.639).

Let $\hat{\delta}_{sup}^i, \hat{\delta}_{inf}^i$ denote respectively the upper bound and the lower bound under complete information (see **Appendix A.6**). By comparison with the boundary under incomplete information, we derive the following lemma.

Lemma 1. i). *In the absence of role redistribution, if and only if the merging firms generate efficiency gains, the merger could be profitable. Moreover, the ceiling of this potential efficiency gains under incomplete information δ_{sup}^i (with $i = A, B$) is smaller than that under complete information.*

ii). *In the presence of role redistribution, i.e. case C and case D, even though the merger leads to efficiency losses, this merger could be profitable. Furthermore, the threshold of potential efficiency losses is larger under incomplete information.*

Proof:

$$\begin{array}{ll}
 \text{Case A:} & \delta_{sup}^A < \hat{\delta}_{sup}^A < 0 & 0 > \delta_{inf}^A > \hat{\delta}_{inf}^A \\
 \text{Case B:} & \delta_{sup}^B < \hat{\delta}_{sup}^B < 0 & \# \\
 \text{Case C:} & \delta_{sup}^C > \hat{\delta}_{sup}^C > 0 & 0 > \delta_{inf}^C > \hat{\delta}_{inf}^C \\
 \text{Case D:} & \delta_{sup}^D > \hat{\delta}_{sup}^D > 0 & 0 > \delta_{inf}^D > \hat{\delta}_{inf}^D \quad \square
 \end{array}$$

As shown in above proposition 2, incomplete information is beneficial to the merged entity in the presence of role redistribution, while it is detrimental to the merged firm in the absence of role redistribution. This permits us to explain the reason why we get to obtain the Lemma 1. In addition, it is obvious that under

²¹Gal-Or (1988) shows that the merged firms respond to market signals less aggressively, which induces non-merged firms to be more aggressive.

incomplete information, the condition that no firm exits the market, is more restrictive.

To sum up, in the current section, we analyze not only the private incentive to merge at the moment when no firm is informed about actual cost of merged entity, but also the profitability of merger at the moment when the merged firm learns its own cost. In addition, by comparing with the scenarios under complete information, the interesting outcomes are achieved. The existing literature explains profitable merger by uncertain efficiency gains or informational advantages. In contrast, we take a different approach to investigate whether increased uncertainty or different types of information structure can promote mergers in sequential Stackelberg game ($m > 2$) [or simultaneous Cournot game ($m = 0$)]. It is shown that without role redistribution, firms have incentives to merge when the uncertainty is sufficiently large, and only mergers generating efficiency gains could be profitable. In the presence of role redistribution, to some extent, the effect of role redistribution can substitute for the uncertainty effect, thereby firms always have incentives to merge even in the situation where the cost uncertainty is very tiny or equal to zero; besides, mergers leading to efficiency losses could be profitable.

1.4 Welfare analysis

We have so far examined firms' incentives to merge and profitability of merger. In this section, we investigate the welfare implications of mergers. The relationship between private intention and collective incentive will also be studied.

The consumer welfare (CS) and social welfare (W) in benchmark are given as follows:

$$CS = \frac{(a - c)^2(n + mn - m^2)^2}{2(m + 1)^2(n - m + 1)^2}$$

$$W = \frac{(a - c)^2[(m + 1)(n - m + 1) + 1](n + mn - m^2)}{2(m + 1)^2(n - m + 1)^2}$$

Aggregate welfare

Since Competition Authorities intervene *ex ante*, they are not informed about the merged firm's cost, it is logical to calculate the welfare implication based on the expected values. As we have demonstrated, both the aggregate surplus and merged entity's profits are increasing functions with respect to the variance σ^2 in four alternative cases (see Remark 1). We compare the level of required uncertainty for profitable merger to that for welfare-enhancing so as to discover the relationship between private and collective incentives.

We model in a very simple way the decision of the Competition Authorities: a merger is approved whenever the expected change is positive. The standard presumption is that without synergies a merger significantly increasing market concentration leads to higher prices, lower aggregate output and lower social welfare. However, in the presence of synergies, welfare may increase. This is a well-known tradeoff between unilateral effects and efficiency gains, to be resolved by the Competition Authorities.

We want to address how this tradeoff is altered by the influence of cost uncertainty²². Consider $\Delta_{\mathbb{E}[W]}^i = \mathbb{E}[W^i] - W$ as the yardstick which judges whether the merger improves the social welfare. In case of $\Delta_{\mathbb{E}[W]}^i > 0$, the merger enhances the welfare, and it will damage the welfare if $\Delta_{\mathbb{E}[W]}^i < 0$.

In order that the merger generates welfare enhancement, the sufficiently large uncertainty is required. Table 1.6 enumerates the thresholds $\sigma_{W_i}^2$ beyond which the merger always gives rise to welfare improvement.

²²As Commissioner Anthony noted in her Synopsis statement, the degree of uncertainty about potential anti-competitive effects and efficiencies is an important factor. The importance of *ex-ante* uncertainty about the effect of mergers is also stressed by PricewaterhouseCoopers (2005) and Competition Commission (2008) in their evaluation reports of merger control policy in the UK.

Table 1.6. Comparison: incentive to merge V s welfare-enhancing

Scenarios	Threshold $\sigma_{W_i}^2$	Welfare-enhancing	
			Comparison with $\sigma_{\pi_i}^2$
Case A	$\sigma_{W_A}^2 = \frac{4(a-c)^2(2m+1)}{m^2(m+1)^2(n-m+1)^2[4(n-m)+3]}$		$\sigma_{\pi_A}^2 > \sigma_{W_A}^2 > 0$
Case B	$\sigma_{W_B}^2 = \frac{4(a-c)\{2(n-m)+1\}+2(m+1)(n-m)[(m+1)(n-m)-2](n-m+1)^2}{3(m+1)^2(n-m+1)^2(n-m)^2}$		1). $\sigma_{\pi_B}^2 > \sigma_{W_B}^2 > 0$ when $n > 6, m \in [3, n-3], a > \Phi + c$
Case C	$\sigma_{W_C}^2 = \frac{4(a-c)^2[(2m+1)(n-m-1)+2n](n-3m-3)}{(m+1)^2(m+2)^2[(n-m)^2-1]^2[5-4(n-m)]}$		2). $\sigma_{W_B}^2 > \sigma_{\pi_B}^2 > 0$ when $n = 6, m = 3$ or $n > 6, m \in [3, n-3], a < \Phi + c$
Case D	$\sigma_{W_D}^2 = \frac{4(a-c)^2[2(n-m)+1]}{[4(n-m)-1](m+1)^2(n-m+1)^2(n-m)^2}$		$\sigma_{W_C}^2 > 0$ ($\nexists \sigma_{\pi_C}^2$)
			$\sigma_{W_D}^2 > 0$ ($\nexists \sigma_{\pi_D}^2$)

$$\text{with } \Phi = \frac{2(m+1)(n-m)(n-m+1)^2[(n-m)(m+1)-2]}{3(n-m)^2-4[2(n-m)+1]}$$

Proposition 3. *Profitable mergers between leaders always constitute a welfare-enhancing merger, that generates the unanimity of private and social incentives. Besides, the merger in case B with large market size could achieve this unanimity.*

Proof:

- (a). *In case of merger between leaders, the magnitude of variance guaranteeing the incentives to merge ensures the enhancement of social welfare without ambiguity. $\sigma_{\pi_A}^2 > \sigma_{W_A}^2 > 0$.*
- (b). *Without role redistribution, whether the merging firms generate the amelioration of welfare depends upon the market configuration (n and m) and the size of market: if the market size is sufficiently large ($a > c + \Phi$), the magnitude of variance guaranteeing the incentives to merge ensures the welfare enhancement; otherwise, the latter covers with the former. $\sigma_{\pi_B}^2 > \sigma_{W_B}^2 > 0$ when $n > 6, m \in [3, n - 3), a > \Phi + c$; otherwise, $\sigma_{W_B}^2 > \sigma_{\pi_B}^2 > 0$.*
- (c). *When two followers result in a newly merged firm behaving as leader, the uncertainty should be greater than the critical value $\sigma_{W_C}^2$ to guarantee the enhancement of welfare. $\sigma_{W_C}^2 > 0$ ($\nexists \sigma_{\pi_C}^2$).*
- (d). *In case of merger between one leader and one follower, as long as the variance is greater than the threshold $\sigma_{W_D}^2$, this merger is always welfare-enhancing and the merging firms always have incentives to merge. $\sigma_{W_D}^2 > 0$ ($\nexists \sigma_{\pi_D}^2$).*

See also Table 1.6. \square .

Consumer welfare (two distinct antitrust criterions)

Although many analyses of mergers focus on an aggregate welfare standard, enforcement practice in most countries (including the US and the EU) is closest to a consumer welfare standard. So a separate analysis of consumer surplus is proposed in this subsection.

Using the similar methods ($\Delta_{\mathbb{E}[CS^i]}^i = \mathbb{E}[CS^i] - CS$), the thresholds $\sigma_{CS^i}^2$ beyond which the merger improves the consumer surplus are derived.

Proposition 4. *Except for the case C, the consumer welfare standard is more rigorous than the total welfare standard.*

Proof: *If Competition Authorities act on the basis of consumer surplus,*

(a). *Profitable merger between leaders requires more uncertainty to guarantee the enhancement of consumer surplus compared to the welfare criterion, i.e.*

$$\sigma_{CS_A}^2 > \sigma_{\pi_A}^2 > \sigma_{W_A}^2 \quad \text{with } \sigma_{CS_A}^2 = \frac{4(a-c)^2(2mn+2m^2n-2m^3-1)}{m^2(m+1)^2(n-m+1)^2}.$$

(b). *In case of the merger between followers without role redistribution, the variance guaranteeing the consumer surplus enhancement ensures the welfare improvement and the private incentive to merge, when the market size is sufficiently large, i.e.*

$$\sigma_{CS_B}^2 > \max\{\sigma_{\pi_B}^2, \sigma_{W_B}^2\} \quad \text{if } a > \Phi + c \quad \text{with } \sigma_{CS_B}^2 = \frac{4(a-c)^2\{2(n-m)[n(m+1)-m^2]-1\}}{(m+1)^2(n-m)^2(n-m+1)^2}.$$

(c). *In case of merged leader firm composed of two followers, when there are enough active firms in market where the proportion of leaders is smaller than followers, the required uncertainty guaranteeing welfare enhancement covers with the one guaranteeing consumer surplus; otherwise, the reverse outcome appears, i.e.*

$$\begin{cases} \sigma_{W_C}^2 > \sigma_{CS_C}^2 & \text{if } n > 12, \quad 3 \leq m < \frac{n}{3} - 1 \\ \sigma_{CS_C}^2 > \sigma_{W_C}^2 & \text{otherwise} \end{cases}$$

$$\text{with } \sigma_{CS_C}^2 = \frac{4(a-c)^2(3m-n+3)\{2(m+1)(m+2)n^2-2mn[2m(m+3)+5]+m[2m(m+1)(m+2)-3]-3(n+1)\}}{(m+1)^2(m+2)^2[(n-m)^2-1]^2}$$

(d). *When the merger is composed of one leader and one follower, the uncertainty guaranteeing consumer surplus improvement ensures the one guaranteeing*

welfare enhancement without ambiguity, *i.e.*

$$\sigma_{CS_D}^2 > \sigma_{W_D}^2 \quad \text{with} \quad \sigma_{CS_D}^2 = \frac{4(a-c)^2 \{2(n-m)[n(m+1)-m^2]-1\}}{(m+1)^2(n-m)^2(n-m+1)^2}. \quad \square$$

As the antitrust decision on the basis of consumer surplus effectively guarantees both the welfare enhancement and the private intention of firms, to some extent, the severity of consumer surplus criterion can be regarded as the precision feature. This precision stems from the fact that the consumer surplus is less sensitive to uncertainty (see Remark 2). The economist's natural reaction to a proposed merger goes something like the following: if a company proposes a takeover, or two companies propose a merger, then we can consider that this transaction will be at least privately profitable²³. This assumption will not, of course, turn out to be correct every time. When firms do not in fact forecast the profitability outcomes of mergers well (even as to the sign of the effects), for example, because of cost uncertainty, then the agencies should not adopt the default assumption that a merger would enhance the producer surplus portion of total welfare simply because the firms have proposed it. Nor should the agencies put much stock in the existence or magnitude of efficiencies claimed by merging parties in their negotiations with the agencies. As Porter (2005) summarizes, "we cannot assume that a merger will be efficient and profitable just because companies propose it." And this leads us to the conclusion that if the analysis of the impact of a merger on competition is implemented under (efficiency or merged firm's productivity) uncertainty, consumer surplus is what agencies and courts do best.

²³Heyer (2006), *supra* note 2, at 38 ("Certainly the merging firms believe that they will be better off, as evidenced by the fact that they have chosen to merge, presumably, voluntarily."). See also Farrell and Shapiro (1990) ("Since any proposed merger is presumably privately profitable, it will also raise welfare if it has a positive external effect [*i.e.*, on consumers and on nonparticipant firms].") and Kaplow and Shapiro (2007), *supra* note 7, at 83 ("The law implicitly presumes mergers to be advantageous to some degree. . . . Setting the threshold of anticompetitive effects significantly above zero may be rationalized by the view that mergers typically generate some synergies, so they should not be prohibited unless the reduction in competition is sufficiently great.").

1.5 *Ex post* merger control

When regulating the behavior of a private party which proposes a merger plan, the Competition Authorities are often uncertain about the sign and extent of the externality due to the shock caused by mergers. However, uncertainty will be disclosed and information on the magnitude of the externality typically becomes available once the merger is consummated. Clearly, the advantage of *ex post* merger enforcement is that it can focus more on (certain) history than on (uncertain) predictions.

In *post merger* game, the insider is able to *first-to-know* its cost and signal this private information through its market conduct. Therefore, when the intervention of antitrust agencies takes place *ex post*, Competition Authorities are aware of the real value of merged firm's cost.

Ex post aggregate welfare criterion

Assume Δ_W^i the difference between the social welfare before and after merger.

$$\Delta_W^i = W^i - W$$

Making use of the similar method in merger's profitability analysis, we try to find the ranges of δ_W^i wherein the merger improves the social welfare (see **Appendix A.7**). Furthermore, by comparing the upper bound of δ_W^i with the critical value δ_{sup}^i demonstrated in merger analysis section, we shed light on the following proposition.

Proposition 5.

- (a). *If the merger is composed of two leaders, the welfare-enhancing merger is not always profitable, but the profitable merger improves social welfare without ambiguity.*
- (b). *When two followers take part in the merger and the newly merged entity behaves as a leader, the welfare-enhancing merger is always profitable, however,*

the profitable merger could damage the aggregate surplus. Furthermore, when there is sufficiently less leader firms in the market, even the profitable merger generating the efficiency losses can enhance welfare.

- (c). *If the merger stems from firms of different types, the welfare-enhancing merger is always profitable.*

Proof:

Case A: $\delta_{sup}^A < \delta_{W_{sup}}^A < 0$

Case B: Complicated (depending upon numerous parameters such as the market size “a”, the marginal cost “c”, the numbers of leaders and followers “n” and “m”, *etc.*)

Case C: $0 < \delta_{W_{sup}}^C < \delta_{sup}^C$, if $n > 12$ and $m \in [3, \frac{n}{3} - 1)$
 $\delta_{W_{sup}}^C < 0 < \delta_{sup}^C$, otherwise

Case D: $\delta_{W_{sup}}^D < 0 < \delta_{sup}^D$ \square

The first key point of this proposition is consistent with Farrell and Shapiro (1990, Proposition 5), Amir et al. (2009, Proposition 4) and Zhou (2008a, Proposition 5) finding that, under some conditions on demand and costs that are satisfied by the linear setting, if a merger with sure efficiency gains is profitable to the merging firms, it will also be welfare-improving.

The second point of proposition is counter-intuitive, it not only analytically demonstrates that the merger generating efficiency losses could be profitable, but also shows that the welfare could be possibly enhanced by the merger even leading to efficiency losses. The reason behind this is two-fold: 1. the role redistribution effect initiated by Daughety (1990), if the merger alters the behavior of the participants, the welfare can be improved by the merger in spite of the lack of synergies;

2. the informational advantage effect explained by several economists (*i.e.* Banal-Estanol, 2007; Amir et al., 2009). The combination of two same-direction effects can be sufficient to compensate the efficiency losses. Thus, it is possible that the “inefficient merger” (which generates efficiency losses) enhances the welfare.

Proposition 5 shows that when intervening *ex post*, Competition Authorities are aware of the merged firm’s cost. Under this circumstance, as long as the merger between leaders is profitable, it is always welfare-enhancing. By contrast, in the three other cases, welfare-improving mergers are unambiguously profitable.

We derive that the profitable merger between leaders is necessarily welfare-improving. It provides support for a *laissez-faire* policy if the decisive criterion rests on social welfare. By contrast, Competition Authorities must supervise more closely bilateral mergers which are consisted of either one or two followers.

***Ex post* consumer welfare criterion**

Suppose Competition Authorities adopt the *ex post* consumer welfare criterion, we find the ranges of δ_{CS}^i wherein the merger improves the consumer surplus. And then we compare the upper bound of δ_{CS}^i , namely $\delta_{CS_{sup}}^i$, with both δ_{sup}^i and $\delta_{W_{sup}}^i$ to achieve the following proposition.

Proposition 6. *If merger regulation occurs after a merger has been consummated, the consumer welfare standard is more lenient than the total welfare standard.*

Proof: *If Competition Authorities act on the basis of actual consumer surplus,*

- (a). *In case A, when there are three or four leaders in pre-merger market, the profitable merger always improves the social welfare, but possibly damages the consumer surplus. When there are more than four leaders in the market, the profitable merger is unambiguously welfare-enhancing and consumer-surplus-*

improving. *i.e.*

$$\begin{cases} \delta_{CS_{sup}}^A < \delta_{sup}^A < \delta_{W_{sup}}^A < 0 & \text{if } m = 3 \text{ or } 4 \\ \delta_{sup}^A < \delta_{CS_{sup}}^A < \delta_{W_{sup}}^A < 0 & \text{if } m \geq 5 \end{cases}$$

$$\text{with } \delta_{CS_{sup}}^A = \frac{-2(a-c)}{m(m+1)(n-m+1)}.$$

- (b). When there are sufficiently less leader firms in the market, the profitable merger generating efficiency losses can improve both consumer and aggregate surplus, and the welfare-enhancing merger ensures the rise of consumer surplus. Otherwise, the efficiency gains are necessary to guarantee the improvement of consumer surplus and welfare, and the merger improving consumer surplus enhances the welfare. *i.e.*

$$\begin{cases} 0 < \delta_{W_{sup}}^C < \delta_{CS_{sup}}^C < \delta_{sup}^C & \text{if } n > 12, m \in [3, \frac{n}{3} - 1) \\ \delta_{CS_{sup}}^C < \delta_{W_{sup}}^C < 0 < \delta_{sup}^C & \text{otherwise} \end{cases}$$

$$\text{with } \delta_{CS_{sup}}^C = \frac{2(a-c)(n-3m-3)}{(m+1)(m+2)[(n-m)^2-1]}.$$

- (c). When the merger is composed of one leader and one follower, the merger improving the consumer surplus is always profitable and welfare-enhancing, *i.e.*

$$\delta_{CS_{sup}}^D < \delta_{W_{sup}}^D < 0 < \delta_{sup}^D \quad \text{with } \delta_{CS_{sup}}^D = \frac{-2(a-c)}{(m+1)(n-m)(n-m+1)}. \quad \square$$

The Propositions 4 and 6 gain some insight into the relationship between the distinct criterions of Competition Authorities and the timing of policy intervention. When Competition Authorities adopt *ex ante* enforcement, antitrust enforcers have less information about the merger, the consumer welfare standard is more *restrictive* than the aggregate welfare standard. By contrast, when Competition Authorities choose *ex post* enforcement, they are aware of the real cost of merged firm, the consumer welfare standard is more *lenient* than the aggregate welfare standard.

1.6 Concluding remarks

This chapter extends the strand of literature on horizontal mergers in a homogeneous oligopoly where there are leaders and followers. Within sequential output decisions, we focus upon the cost uncertainty and the efficiency gains (or losses), in order to fulfill the gap of merger issue under uncertainty. In this model, the merger decision is made before firms learn the merged firm's cost. We find that the expected profit of merged firm grows following the enlargement of variance. When the extent of variance exceeds a certain threshold, firms facing uncertainty choose to merge. On the other hand, if there is role redistribution, even in the absence of uncertainty effect, firms have incentives to merge.

In terms of profit, we analyze the profitability of merger in context of informational asymmetry. It is shown that the two-follower merger aiming to a leader strategy occurs more likely than the one satisfying *status quo*. Furthermore, the merged firm has interests to pool the private signals to outsiders, in the absence of role redistribution. By contrast, in the presence of role redistribution, the concealment is more profitable from the viewpoint of insider.

In terms of welfare, it is found that the merger between leaders always enhances welfare if participants have incentives to merge, this generates the unanimity of private and collective intentions. Nevertheless, the merger with role redistribution leads to the private-collective conflict. From the standpoint of Competition Authorities, after separately studying the two possible criterions: "aggregate welfare standard" and "consumer welfare standard", we find that the latter is more *restrictive* and more *accurate* than the former in an uncertain environment. In addition, by carrying on a separate analysis of *ex post* enforcement merger control, we gain some insight into the relationship between the distinct criterions of Competition Authorities and the timing of policy intervention.

We have restricted our analysis to a bilateral merger. A generalization would be to consider the merger composed of more than two firms, in order to relax the assumption and check the robustness of this framework. Another direction would

be to take into account the *Endogenous Stackelberg* issue in the context of cost uncertainty.

Entry mode choice and target firm selection

Abstract: *The purpose of this chapter is to formalize the choices of market entry strategy (Export, Greenfield investment, Cross border M&A) and the target selection (Acquisition of high-productivity firm or low-productivity one) for a foreign firm, and to delineate the relationship between foreign firm's incentive and host government's intention. It is found that cross border M&A is always the most profitable entry mode under both greenfield investment and export credible threats. If greenfield FDI is viable, entering firm prefers acquiring the low-productivity firm, when the integration ability is strong and the technological gap is sufficiently small; otherwise it prefers high-productivity one. Moreover, there is always the ambiguity between the foreign firm's preference and the government's judgment. If export entry option is viable, the variation of trade cost will alter the choice of target firm by the influence of acquisition price. The higher the trade cost, the more likely foreign firm purchases low-technology firm. In addition, the unanimity of private and collective incentive appears under certain circumstances.*

2.1 Introduction

In an increasingly globalized world, the decision of how best to serve foreign markets is becoming one of the key challenges facing firms. A firm that has decided to sell its product abroad has two distinct options of serving foreign markets: exporting or producing locally by Foreign Direct Investment (FDI). As well as seeing an increase in total FDI, cross border M&As increase¹ in importance relative to greenfield investment. Consequently, the attention is shifted to the composition of FDI as firms can choose between different types of FDI².

Despite this increased importance of cross border M&A, the determinants underlying such activities remain unclear. There have been a fair number of papers written about cross border M&A versus greenfield investment, and some include a third option for a foreign firm such as exporting³. The existing theoretical literature on foreign firm's entry modes is separated into three important areas. One strand explores strategic aspects of the FDI/trade decision, such as tariff jumping FDI (e.g., Horstmann and Markusen, 1992; Motta, 1992; Buckley and Casson, 1998), a second set of models analyzes the choice between FDI greenfield and acquisition (e.g., Hennart and Park, 1993; Mueller, 2001; Görg, 2000; Haller, 2009) in the absence of trade costs, and a third category examines entry mode selection/firm's heterogeneity (e.g., Head and Ries, 2003; Helpman, Melitz and Yeaple, 2004; Nocke and Yeaple, 2007). We combine key aspects of each of the previous approaches to construct one integrated theoretical framework that allows for all three entry modes, namely Export, Greenfield investment and Cross border M&A⁴.

¹Caldron et al., (2002) report that M&A activity almost doubled as a percentage of GDP (and increased as a share of total investment) in industrialized countries between the late 1980s and the late 1990s. Meanwhile, in developing countries, M&A is more than nine times as high as a share of GDP compared to 1987-1989. The bulk of FDI actually belongs to M&A activity, over eighty percent in 1999 according to UNCTAD (2000), or according to Head and Ries (2008) for the years between 1987 and 2001, two thirds of total FDI.

²Although FDI has received an enormous amount of attention in the literature, most of this literature has dealt exclusively with a single mode of FDI, mainly greenfield investment, and to a lesser extent with cross border M&A.

³Theoretical work starts to emphasize cross border M&A and greenfield investment as two modes of foreign direct investment and alternatives to exporting as a way to enter foreign markets only recently (Nocke and Yeaple, 2007)

⁴In practice, world M&A have been predominantly driven by acquisitions. Cross border

This allows us to examine the determinants of foreign firm's entry decisions as a function of trade costs, FDI fixed costs, firm heterogeneity and market characteristics.

Apart from discussing three alternative entry modes, we regard the main contribution of this chapter as being two-fold. First, while most of the existing models on cross border M&A do not focus on the target firm selection (because they simply assume domestic firms are identical), the current chapter considers a target choice process when several domestic firms accept the M&A proposal. This allows us to investigate how the relevant factors (*i.e.*, the technological gap, integration ability, trade cost) affect the acquisition target choice. Second, we incorporate active host government judgment within our entry mode choice framework. In particular, consistent with what happens in most countries, we assume that the foreign firm must notify project (or decision) to the government in host country, which can either authorize or block the foreign firm's plan. The host government decision is taken in order to authorize the entry mode which improves the most welfare of host country⁵. In such a context, analyzing the optimal entry mode involves not only a standard firm's private incentive analysis, but also a study of the strategic interaction between the foreign firm and the host government which is regarded as a screening device to foreign firm's decision. The clash between the foreign firm's equilibrium choice and the local government's ranking of the three modes of entry can provide a rationale for some frequently observed market access restrictions.

The main purpose of this chapter is to formalize the choices of market entry strategy and the target selection for a foreign firm, and to delineate the relationship between foreign firm's incentive and host government's intention. To realize this objective, we suppose that firms with different productivity levels coexist, and the foreign entering firm is assumed to be more efficient than the firms in host country. This assumption is consistent with the common observation⁶ in Central and

mergers represented only 3% of cross border M&As in 1999 (UNCTAD 2000). This is the reason why we focus upon the acquisition rather than mergers in this framework.

⁵The host country welfare is measured by the sum of consumer's surplus and domestic firm's profits, and acquisition payment in case of M&A.

⁶See Müller (2000).

Eastern Europe (CEE). Empirical evidence⁷ confirms the potential entrant's superior technology. In addition, Helpman et al. (2004) highlight the important role of within-sector firm productivity differences and demonstrate that only the most productive firm engages in foreign activities. The gap of productivity (or technology) is introduced and aims to measure the firm heterogeneity. It could also be used to delineate the heterogeneity of technological know-how in R&D-intensive industries and that of marketing expertise in advertising-intensive industries.

The innovative aspect of this model is how the foreign entering firm's superior technology is transferred. The new plant constructed by foreign firm *via* greenfield investment can fully use the foreign firm's advanced technology, however, the superior technology will be partially transferred to the local acquired firm. We emphasize the word "partially" because the newly acquired firm's productivity will be inbetween the productivity of the two firms participating in the M&A. For instance, following the M&A deal between Renault and Nissan in 1999, Renault installed one of its top managers, Carlos Ghosn, as Nissan's CEO. He restructured Nissan and brought it back to profitability. It is this transfer of expertise and technology that we model.

Furthermore, the acquisition integration ability is also the relevant factor which affects the productivity of newly merged firm. This integration problem stems from in general the existence of the relative disadvantage of the foreign firm to a local firm in an unfamiliar environment or arises from the different company cultures. According to Hennart (1988), the post-acquisition integration problem can be neglected for the greenfield entry mode, but should be pinpointed for the cross border M&A. Therefore, the impact of integration ability is taken into account in our entry mode analysis, in particular, in the case of cross border M&A⁸.

⁷Empirical evidence shows that exporters are more productive than non-exporters (see Bernard and Jensen (1999), Aw, Chung and Roberts (2000) and Clerides, Lach and Tybout (1998)), firms engaging in FDI are more productive (see Helpman (2006)) and within the group of firms choosing FDI as an option for entering the foreign market, the more productive ones are involved in FDI (see Yeaple (2008)).

⁸In addition to the effect of the market structure associated with the entry mode, the influence of an exogenous change in the competition intensity on the entry mode preference is analyzed. After the M&A of one local firm, the number of firms competing in the host market is reduced (soften competition) while both export and greenfield investment entry mode lead to a more

Without loss of generality, export implies additional trade cost, greenfield investment involves a sunk cost for installing a new plant, while cross border M&A incurs the cost for purchasing the asset of the existing firm in the host country. It is worthwhile to note that this acquisition cost depends not only upon foreign firm's target selection (namely, the acquisition of high-productivity firm is more expensive than the purchasing of low-productivity one.), but also on the outside credible alternative, which emphasizes the interdependence of three alternative entry options.

In the absence of the government intervention, the timing of the game is as follows: the foreign firm submits a *take-it-or-leave-it* offer to both high-technology firm and low-technology firm simultaneously, and these two local firms can either reject or accept this proposal. If no local firm accepts the offer, the foreign firm decides whether to engage in greenfield investment or to export; if one local firm accepts the proposal, the foreign firm pays the amount of reservation profit of the target firm to enter the market; if both local firms accept, this foreign firm will select the local firm with which it earns more profit. Finally, all independent firms compete in Cournot fashion. Notice that letting foreign firm firstly make a cross border M&A proposal doesn't restrict its ability to choose greenfield investment or export, it can simply propose an unacceptably small payment to target firm if the foreign firm prefers greenfield investment to M&A⁹.

We find that cross border M&A is always the most profitable entry mode under both greenfield investment and export credible threats. If greenfield investment is viable, the foreign firm acquires the low-productivity firm when the integration ability is strong and the technological gap is sufficiently small; by contrast, the foreign firm has interest to acquire the high-productivity firm when the integration ability is sufficiently weak and the gap is comparatively large, and this outcome can be irreversible when either the technological gap or the integration ability satisfies some conditions. If the export entry mode is viable, we shed light on the competitive situation.

⁹See Raff, Ryan and Stähler (2009)

fact that the variation of trade cost will alter the choice of target firm through the influence of acquisition price. The higher the trade cost is, the foreign firm has more incentive to purchase low-technology firm.

With incorporating the host government decision, the entry mode, which generates the harmonization of private and collective incentives, is authorized; whereas, the strategy leading to conflict will be prohibited by government. We demonstrate that under greenfield investment credible threat, foreign firm decides not to enter the host market in the context of export strategy improving the most welfare, but it could abandon the M&A plan and choose greenfield investment when greenfield FDI enhances the most welfare. If the export option is viable, we demonstrate that the foreign firm has no chance to adopt the cross border M&A strategy to enter the host market when firm's integration ability is "minimum" or "medium".

This chapter is organized as follows. In the next section, the hypothesis and three alternative entry modes of the game are presented. In Section 2.3, we analyze the sub-game of the whole game and demonstrate how to deduce the optimal entry mode under greenfield investment and export credible threats respectively. Section 2.4 focuses on the social welfare of host country through the impacts on the entry mode choice of foreign firm, and tracks the issue of foreign market access and host government decision. Section 2.5 concludes this chapter.

2.2 The Model

Hypothesis

We consider an international oligopoly model where firms with different productivity levels coexist. There are two domestic (or local) firms, H and L . They differ in their level of marginal cost (or productivity), firm L attributed to the "Low marginal cost (high-productivity) enterprise" is more efficient than firm H : $c_H \geq c_L$. The potential entrant F is assumed to be more efficient than domestic firms, its marginal cost is given by c , where $c \leq c_L \leq c_H$.

To simplify, we suppose that the gap between two closer productivity (or technology) levels is identic and equal to “ s ”. The relationship between single foreign firm and two local firms is established in terms of marginal cost, namely, $c_H - c_L = c_L - c = s$. The parameter s signifies the gap of productivity (or technology) between firms, and it can also measure the firm heterogeneity. The larger the gap s , the more heterogenous firms.

Firms are producing a homogenous good. Hence, demand is the same for all firms with the inverse demand function given by $p = a - Q$, where “ a ” represents the size of market and “ Q ” denotes the sum over all firms’ sales. For firms to produce positive levels of output, we require $a > c_H \geq c_L \geq c > 0$

Firm F decides to sell its products abroad and has two distinct options of serving foreign markets: exporting or producing locally as FDI. If the foreign firm serves the market by exports, export implies additional marginal (and unit) trade cost “ t ”. If firm F decides to produce locally, it can choose between different types of FDI: greenfield investment or cross border M&A. The former involves a fixed cost¹⁰ (sunk cost) “ f ” in building new plant, while the latter involves the cost for purchasing the asset of the existing firm (either firm H or firm L) in the host country at the amount of “ μ_i ” with $i = \{H, L\}$.

The timing of the game is as follows:

Stage 1: Firm F submits a *take-it-or-leave-it* offer to both local firm H and firm L , and these two local firms can either reject or accept this proposal.

- If neither firm accepts the offer, the foreign firm decides whether to engage in greenfield investment or to export.
- If one local firm accepts the proposal, firm F pays the acquisition price for the target firm to enter the market.

¹⁰We make the simplifying assumption that the other FDI mode do not involve fixed cost. Hence one can view “ f ” as the differential fixed cost of greenfield investment relative to M&A.

- If both local firms accept, firm F will select only one of the local firms with which the foreign firm can earn more.

Stage 2: All independent firms compete in Cournot fashion.

Note that letting foreign firm firstly make a cross border M&A proposal doesn't restrict its ability to choose greenfield investment or exporting, it can simply propose an unacceptably small payment to target firm if the foreign firm "dislikes" M&A.

The exogenous parameter $\theta \in [0, 1]$ measures the integration ability¹¹. After the takeover target is bought, the acquired firm obtains a new productivity level which depends on its productivity before M&A, the technological gap between firms, the integration ability. The marginal cost of new firm M arising from acquisition is expressed as:

$$c_M = c\theta + c_i(1 - \theta)$$

$$\text{with } c_i = \{c_L, c_H\}$$

Different Modes of Entry

We turn to the equilibrium analysis of this model and determine the equilibrium pattern of greenfield investment, export and cross border M&A. To derive the foreign firm's optimal entry mode, we search for sub-game perfect equilibria through backward induction.

Greenfield Investment

Greenfield investment, denoted by the superscript "G", allows the foreign firm to produce locally in the host market. The total cost for the foreign firm is $cq_F + f$, where f is the plant specific fixed cost, and the marginal cost of the affiliated plant reflects the cost of foreign firm¹² c , q_F represents the foreign firm's output sold in

¹¹The integration ability can be regarded as cultural and geographical proximity which is studied by Di Giovanni (2005) and Head and Ries (2007) using respectively Tobit and Poisson Maximum Likelihood method.

¹²This assumption is based on the fact that the profit maximization strategy of a multinational

the host country¹³.

The profits of the foreign firm and the domestic firms are then defined as follows

$$\begin{aligned}\pi_F^G &= (p - c)q_F^G - f \\ \pi_i^G &= (p - c_i)q_i^G \text{ with } i = \{L, H\}\end{aligned}$$

We henceforth note $A = a - c$ for simplicity. The equilibrium outputs and profits are then shown in Table 2.1:

Different firms	Equilibrium	
	Output	Profit
Firm F	$q_F^G = \frac{A+3s}{4}$	$\pi_F^G = \frac{(A+3s)^2}{16} - f$
Firm L	$q_L^G = \frac{A-s}{4}$	$\pi_L^G = \frac{(A-s)^2}{16}$
Firm H	$q_H^G = \frac{A-5s}{4}$	$\pi_H^G = \frac{(A-5s)^2}{16}$

Table 2.1. Equilibrium in Greenfield Investment

Note also that the technological gap s ought to be less than $\frac{1}{5}A$ in order to ensure the interior solution ($q_H^G \geq 0$). Then the lower and upper bounds of a subset s are respectively zero and $\bar{s} = \frac{1}{5}A$.

Export

There is an additional trade cost of size t per unit, when the foreign firm chooses export denoted by “ E ”. The equilibrium output and profit of each firm are shown in Table 2.2

firm drives the affiliate firm in the host country to use the same profit maximizing technology as the parent firm.

¹³The fixed cost can be differentiated into plant specific fixed cost and firm specific fixed cost when FDI types are differentiated into vertical FDI and horizontal FDI. Markusen (2003) and Navaretti and Venables (2004) provide classic definition of horizontal FDI and vertical FDI as follows “Horizontal direct investment refers to the foreign production of products and services roughly similar to those the firm produces for its home markets. Vertical investment refers to those that geographically fragment the production by stages of production. By horizontal FDI, we refer to firms producing roughly the same final products in multiple countries even though foreign plants are supplied with headquarters services. Vertical firms generally produce outputs not produced by the parent-country operation. A parent firm may ship designs and/or intermediate inputs to a foreign assembly plants and export the final output back to the parent country market.”

Different firms	Equilibrium	
	Output	Profit
Firm F	$q_F^E = \frac{A+3s-3t}{4}$	$\pi_F^E = \frac{(A+3s-3t)^2}{16}$
Firm L	$q_L^E = \frac{A-s+t}{4}$	$\pi_L^E = \frac{(A-s+t)^2}{16}$
Firm H	$q_H^E = \frac{A-5s+t}{4}$	$\pi_H^E = \frac{(A-5s+t)^2}{16}$

Table 2.2. Equilibrium in Export

Notice that $0 < t \leq \bar{t}$ with $\bar{t} = \frac{A}{3}$. This assumption guarantees the non negativity of prices and ensures the possibility for all firms to be active.

Cross border M&A

When the foreign firm chooses to enter the host market by cross border M&A, denoted by the superscript “M”, the competition in the market is reduced. The cost of M&A for foreign firm is the purchasing price of the target firm i , which should be at least the same or larger than the target firm’s reservation profit level. It is equivalent to this firm’s profit level under greenfield investment or under export mode. The foreign firm’s total cost when it chooses cross border M&A will be

$$c_M q_M + \mu_i = [c\theta + c_i(1 - \theta)]q_M + \mu_i$$

with $i = \{L, H\}$, where μ_i is the acquisition price¹⁴ for the purchase of local firm i .

Since the foreign firm can purchase either local firm L or firm H , there are two possibilities. We begin with the scenario where the firm L is acquired. Consider the newly acquired entity as firm “ ML ” which signifies the new entity achieved by purchasing firm L , then the model reduces to a duopoly game in which firm ML

¹⁴The acquisition price obviously depends on the bargaining power of the entrant and the incumbents. Other bargaining solutions, where the local firm has some bargaining power, would lead to a higher acquisition price and therefore shift preferences of the multinational firm in favor of greenfield investment or export. Assuming full bargaining power of the entrant instead, at least constitutes a lower bound for the acquisition price.

and firm H compete. The respective profit levels are equal to

$$\begin{aligned}\pi_{ML}^M &= \frac{(A + 2\theta s)^2}{9} - \mu_L \\ \pi_H^M &= \frac{(A - 3s - \theta s)^2}{9}\end{aligned}$$

When foreign firm F acquires the low productivity firm H , the equilibriums are given by:

$$\begin{aligned}\pi_{MH}^M &= \frac{[A - s(3 - 4\theta)]^2}{9} - \mu_H \\ \pi_L^M &= \frac{(A - 2\theta s)^2}{9}\end{aligned}$$

In the following section, we compare the alternative entry modes and carry out the equilibrium dominance analysis.

2.3 Profit analysis and comparison

Credible threat: Greenfield investment Vs Export

The incentive for the shift of multinational firm's entry mode from export to greenfield investment is affected by the rise of trade cost. However, when the sunk cost for greenfield investment is relatively high, there is no incentive for the foreign firm to choose greenfield investment entry mode. By comparing foreign firm's profit in greenfield investment (π_F^G) option to that in export option (π_F^E), we can derive the credible threat condition.

Through $\pi_F^G = \pi_F^E$, the expression of f^* is found:

$$f^* = \frac{3t(2A + 6s - 3t)}{16}$$

Obviously, the foreign firm will prefer greenfield investment to exporting when the sunk cost f is less than f^* . Notice that $f \leq f^*$ is also the condition for

greenfield investment to be a credible threat if the cross border M&A proposal is rejected. For instance, suppose $f \leq f^*$ is fulfilled, when *take-it-or-leave-it* offer is rejected by local firm, the entrant can credibly commit to greenfield investment entry, then the acquisition price μ_i^G will clearly be equal to local firm i 's post-greenfield profit π_i^G , thereby, any cross border M&A proposal larger or equal to $\mu_i^G = \pi_i^G$ (with $i = \{L, H\}$) will be accepted by local firm i . If this condition is not fulfilled ($f > f^*$), cross border M&A will be accepted if and only if the foreign firm can afford to pay the acquisition price (μ_i^E) which is larger or equal to π_i^E . It is noticeable that the acquisition payment under greenfield investment credible threat is lower than that under export credible threat, because of $\pi_i^G < \pi_i^E$.

Greenfield investment credible threat ($f \leq f^*$)

Under this credible threat, greenfield investment is more profitable than export, it is clear that the foreign firm prefers greenfield investment to export as the market entry mode. We will firstly investigate whether the foreign firm has interest to enter the host market by M&A. If the answer is 'yes', which one the foreign firm prefers purchasing ?

Since the acquisition price μ_i , in turn, depends upon the credibility of greenfield investment or export, the acquisition price for potential target firm L or H under greenfield investment credible threat will respectively be:

$$\begin{cases} \mu_L^G &= \pi_L^G = \frac{(A-s)^2}{16} \\ \mu_H^G &= \pi_H^G = \frac{(A-5s)^2}{16} \end{cases}$$

Clearly, for a cross border M&A to be profitable, the willingness to pay on the part of the acquiring firm should be equal to or exceed the reservation price of the target firm.

Result 1. *The foreign firm has always the incentive to enter the host country by cross border M&A under greenfield investment credible threat.*

Proof: If the foreign firm F decides to purchase the domestic firm L , the profit of the new entity is

$$\pi_{ML}^M = \frac{(A + 2\theta s)^2}{9} - \mu_L^G = \frac{(A + 2\theta s)^2}{9} - \frac{(A - s)^2}{16} > 0$$

If the firm F chooses the target firm H , the profit is

$$\pi_{MH}^M = \frac{[A - s(3 - 4\theta)]^2}{9} - \mu_H^G = \frac{[A - s(3 - 4\theta)]^2}{9} - \frac{(A - 5s)^2}{16} > 0$$

□

Since both these acquisition manners are profitable, the foreign firm has to decide which one it prefers. The profit of the new entity achieved by acquiring firm L and that realized by purchasing firm H are compared. Suppose $\Delta^G \pi^M$ the difference¹⁵ between π_{ML}^M and π_{MH}^M .

$$\Delta^G \pi^M = \pi_{ML}^M - \pi_{MH}^M = \frac{s[3 - 8\theta + 3s(3 + 16\theta - 8\theta^2)]}{18}$$

The condition $\Delta^G \pi^M > 0$ implies that the profit of the new entity by purchasing firm L exceeds that by acquiring firm H , in other words, there is an advantage for foreign firm to acquire high-productivity (Low marginal cost) firm L ; whereas $\Delta^G \pi^M < 0$ sheds light on the advantage of purchasing low-productivity (High marginal cost) firm H . Evidently, the foreign firm has no target preference while $\Delta^G \pi^M = 0$.

Result 2. Under greenfield investment credible threat, the foreign firm F will select the low-productivity (High marginal cost) firm H , if the technological gap is sufficiently small and the integration ability is comparatively strong; otherwise, the firm F will choose the high-productivity (Low marginal cost) firm L as target.

Proof:

Firm F selects firm L ($\Delta^G \pi_M^M > 0$), if

¹⁵Without loss of generality, the assumption $A = 1$ is henceforth taken into account for simplifying the model.

- $0 \leq \theta \leq \frac{3}{8}$
- $\frac{3}{8} < \theta \leq 1$ and $\frac{3-8\theta}{3(8\theta^2-16\theta-3)} < s < \bar{s}$

Firm F selects firm H ($\Delta^G \pi_M^M < 0$), if $\frac{3}{8} < \theta \leq 1$ and $0 < s < \frac{3-8\theta}{3(8\theta^2-16\theta-3)}$ \square

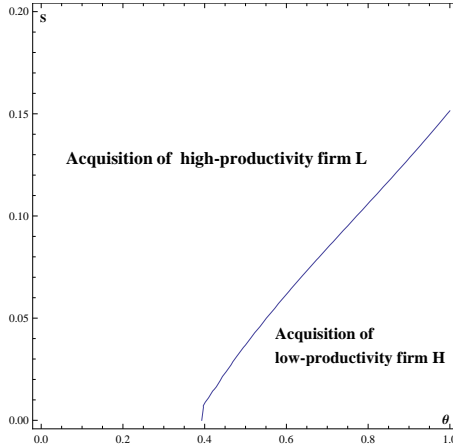


Figure 2.1. Acquisition target selection under greenfield investment threat

The intention to acquire the low-productivity firm is explained by the following reasons: 1). the high value of θ allows large technologic transfers by which the marginal cost (or productivity) of newly acquired firm MH can be tremendously reduced (or improved); 2). the small gap making firms less heterogenous, lessens the impact of target firm choice; 3). the payment to acquire firm H is less than the price acquisition of firm L ($\mu_H^G < \mu_L^G$). Therefore, purchasing low-productivity firm H is more profitable in this situation. By contrary, the foreign firm has interest to acquire high-productivity firm when the integration ability is sufficiently weak and the technological gap is comparatively large. Under this circumstance, the gains arising from purchasing firm L effortlessly compensate the payout which is much higher than the outlay of purchasing firm H . This makes acquisition of firm L more beneficial.

It is worth while to note that the foreign firm is willing to acquire firm L when the integration ability θ is sufficiently weak ($\theta < \frac{3}{8}$), and this outcome is independent of the technological gap. Moreover, when the technological gap exceeds the

threshold $(\frac{3-8\theta}{3(8\theta^2-16\theta-3)})$, the foreign firm has incentive to purchase firm L regardless of the integration ability.

Export credible threat ($f > f^*$)

Under export credible threat, the acquisition price for potential target firm L or H will respectively be

$$\begin{cases} \mu_L = \pi_L^E = \frac{(A-s+t)^2}{16} \\ \mu_H = \pi_H^E = \frac{(A-5s+t)^2}{16} \end{cases}$$

Result 3. *The foreign firm has always the incentive to enter the host country by cross border M&A under export credible threat.*

Proof: *In case of purchasing the target firm L , the profit of the new entity is*

$$\pi_{ML}^M = \frac{(A+2\theta s)^2}{9} - \mu_L^E = \frac{(A+2\theta s)^2}{9} - \frac{(A-s+t)^2}{16} > 0$$

In case of purchasing the target firm H

$$\pi_{MH}^M = \frac{[A-s(3-4\theta)]^2}{9} - \mu_H^E = \frac{[A-s(3-4\theta)]^2}{9} - \frac{(A-5s+t)^2}{16} > 0$$

□

Assume $\Delta^E \pi^M$ the difference between π_{ML}^M and π_{MH}^M under export credible threat.

$$\Delta^E \pi^M = \pi_{ML}^M - \pi_{MH}^M = \frac{s[3-9t-8\theta+3s(3+16\theta-8\theta^2)]}{18}$$

The foreign firm acquires firm L when the difference of profit ($\Delta^E \pi^M$) is positive; the firm H will be the target while $\Delta^E \pi^M < 0$.

We demonstrate that under export credible threat, the foreign firm F will acquire the high-productivity (Low marginal cost) firm L ($\Delta^E \pi^M > 0$) if

- $\theta = 0$

- $0 < \theta < \frac{1}{3}$ and $\begin{cases} 0 < s \leq \frac{1}{6-3\theta} \text{ and } 0 < t < \hat{t} \\ \frac{1}{6-3\theta} < s < \bar{s} \end{cases}$
- $\frac{1}{3} \leq \theta \leq \frac{3}{8}$ and $0 < t < \hat{t}$
- $\frac{3}{8} < \theta \leq 1$ and $\frac{3-8\theta}{3(8\theta^2-16\theta-3)} < s < \bar{s}$ and $0 < t < \hat{t}$

otherwise, the firm F will purchase the low-productivity (High marginal cost) firm H ($\Delta^E \pi^M < 0$). Note that $\hat{t} = \frac{3+9s-8\theta+48s\theta-24s\theta^2}{9}$.

In order to show the above-mentioned finding more visually, we illustrate it with Figure 2.2 assuming the discrete values for trade cost $t = \{0, \frac{\bar{t}}{4}, \frac{\bar{t}}{2}, \frac{3\bar{t}}{4}, \bar{t}\}$. This assumption allows us to explain how a variation in trade costs can trigger two channels of cross border M&A (either F_L or F_H).

Using the similar *quomodo*, we draw the curve $\Delta^E \pi^M$ with discrete values for integration ability $\theta = \{0, \frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\}$ in the pattern (Figure 2.3) where the horizontal axis represents the trade cost and the vertical axis delineates the technological gap.

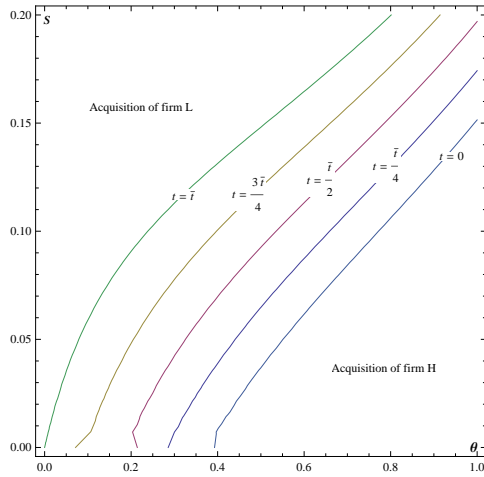


Figure 2.2. Choice of acquisition target under export threat (θ, s)

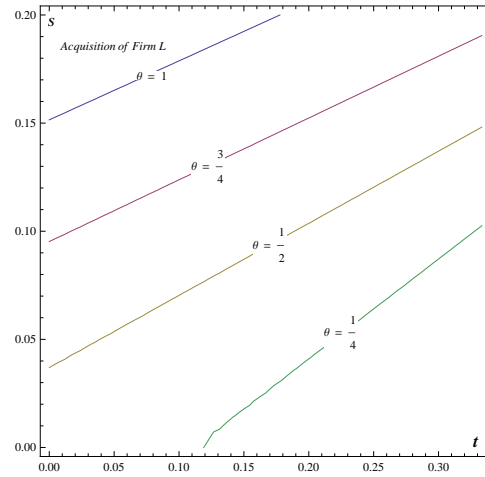


Figure 2.3. “Acquisition of Firm L” area under export threat (t, s)

According to Figure 2.2, the higher the trade cost, the larger the surface where foreign firm has incentive to purchase firm H . The variation of trade cost alters

the choice of target firm through the influence of acquisition price. Although the rise of trade cost increases both the payments of purchasing firm L and firm H , the sensibility relative to trade cost is given by,

$$\frac{\partial \mu_L^E}{\partial t} > \frac{\partial \mu_H^E}{\partial t} > 0$$

Following an increase of t , the M&A cost of acquiring firm L increases more rapidly than the cost for purchasing firm H . This could make the acquisition of firm L less beneficial and give rises to the diminution of the area where the purchase of firm L prevails over the acquisition of firm H .

Figure 2.3 describes the foreign firm's selection propensity with respect to the integration ability. In particular, when $\theta = 0$, the marginal cost of newly acquired firm M reflects its own initial productivity level, therefore, the foreign firm looking for a takeover target would want to acquire the more efficient domestic firm (low marginal cost firm L). However, following an increase of integration ability, the advantage of taking over the less efficient domestic one emerges, in virtue of large scale of technologic transfer and comparatively lower acquisition price. In the case of max value of θ , there is a very small area left for "Acquisition of Firm L ".

To sum up, in the private profit analysis, the foreign firm is always willing to enter the host market by cross border M&A under both greenfield investment credible threat and export credible threat. The technological gap and the integration ability evidently affect the selection of target firm. In addition, the trade cost alters this selection decision under export credible threat.

In the following section, we will proceed the in-depth analysis from the viewpoint of welfare, find out the welfare dominant entry mode for the host country, and try to systematically combine the issue of foreign market access and the (host) government decision.

2.4 Welfare analysis and host government judgment

Drawing on the traditions of both industrial organization and international trade theories, permits a game-theoretic approach to explaining FDI and export activities. At the same time, it is a completely specified general equilibrium model, making it possible to track the issue of foreign market access and host country decision. In this current section, we incorporate active host government judgement within our entry mode choice framework. The foreign firm notifies entry projet to the host government, and the host government can either authorize or block the foreign firm's plan.

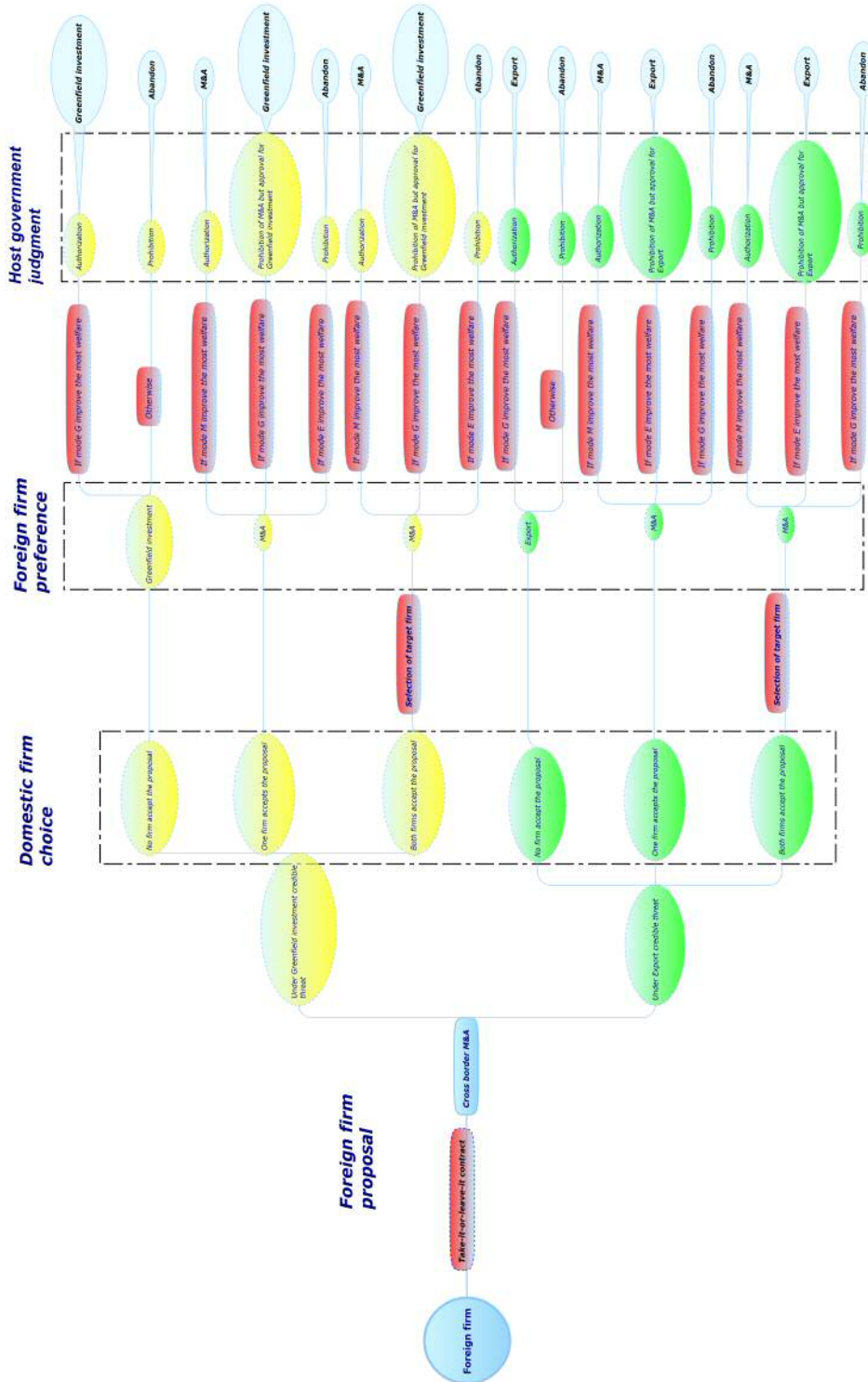


Figure 2.4. Game structure

The structure of the game is outlined in Figure 2.4. The government considers the host country welfare¹⁶ as criterion. As we have demonstrated, in the previous profit analysis section, that the foreign firm has always incentive to enter the host market by cross border M&A, the interaction of foreign firm and host government can be described as follows:

- *Under greenfield investment credible threat*, if cross border M&A enhances the most host welfare, M&A is authorized by government; if greenfield investment improves the most host welfare, government blocks the M&A projet but approves greenfield FDI, then the foreign firm abandons M&A and chooses greenfield investment; if export enhances the most host welfare, the foreign firm decides not to serve the host market because of the conflict between the private incentive and the social intention.
- *Under export credible threat*, in case of cross border M&A enhancing the most welfare, M&A is authorized, then foreign firm chooses cross border M&A; in case of greenfield investment improving the most welfare, the foreign firm decides not to serve the host market; in case of export enhancing the most welfare, the government blocks the M&A projet but approvals export, thereby the foreign firm abandons M&A and chooses export.

The equilibrium social welfare levels of the host country under greenfield investment, export and cross border M&A options are given as follows:

$$W^j = PS^j + CS^j \quad \text{with } j = \{E, G, M\}$$

Greenfield investment ($j = G$):

$$W^G = \pi_H^G + \pi_L^G + \frac{1}{2}(q_F^G + q_H^G + q_L^G)^2$$

¹⁶Since the welfare level in the situation without foreign entry is always lower than that with foreign entry, it is sufficient to compare welfare outcomes of the different entry modes.

Export ($j = E$):

$$W^E = \pi_H^E + \pi_L^E + \frac{1}{2}(q_F^E + q_H^E + q_L^E)^2$$

Cross border M&A ($j = M$):

- Under Greenfield investment credible threat:

- In case of acquiring F_L : $W_{G,L}^M = \pi_H^M + \frac{1}{2}(q_{ML}^M + q_H^M)^2 + \mu_L^G$

- In case of acquiring F_H : $W_{G,H}^M = \pi_L^M + \frac{1}{2}(q_{MH}^M + q_L^M)^2 + \mu_H^G$

- Under Export credible threat:

- In case of acquiring F_L : $W_{E,L}^M = \pi_H^M + \frac{1}{2}(q_{ML}^M + q_H^M)^2 + \mu_L^E$

- In case of acquiring F_H : $W_{E,H}^M = \pi_L^M + \frac{1}{2}(q_{MH}^M + q_L^M)^2 + \mu_H^E$

Notice that the subscripts ‘G’ and ‘E’ of welfare signify the greenfield credible threat and the export credible threat respectively. The acquisition payment ‘ μ ’ is part and parcel of host country welfare, because it can be considered as the local target firm’s profit earned by selling itself. See the expressions of social welfare in **Appendix B.1**.

The welfare dominant entry mode can be determined by the comparison of the host country’s equilibrium social welfare with three alternative entry options. Let us begin with the simple comparison between W^G and W^E .

Result 4. *Greenfield investment can improve more welfare than export entry mode, when the technological gap is strong and the trade cost is comparatively small. Precisely,*

- $W^G > W^E$, if $t \in (0, \frac{8}{25})$ and $s \in (\frac{2+5t}{18}, \bar{s})$
- $W^G < W^E$, otherwise

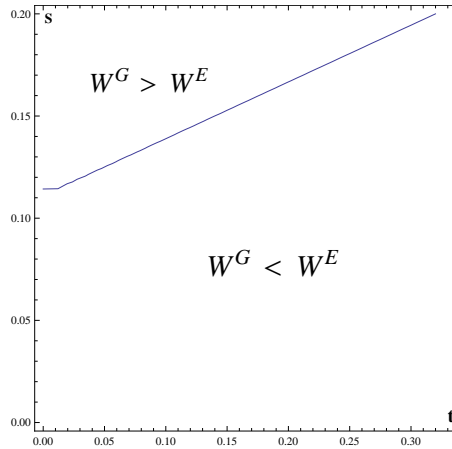


Figure 2.5. Social welfare: Greenfield investment Vs Export

As demonstrated in the previous section, the sum of the local firms' profits (producer surplus) in export option is higher compared to greenfield investment option, due to transportation costs. However, these transportation costs also imply that the aggregate output in option E in the presence of the trade cost are always less than the aggregate quantities in greenfield investment option, it means that greenfield investment generates more consumer surplus. Consequently, whether greenfield investment or export could improve more host welfare, depends on the tradeoff of producer and consumer surplus.

According to Figure 2.5, it is clear that the social welfare level within greenfield investment is higher than that within export as long as the technological gap among firms is higher than a critical value. Moreover, this critical value ($\frac{2+5t}{18}$) depends on the trade cost and it augments following an increase of trade cost. In contrast, when the trade cost is sufficiently large ($t > \frac{8}{25}$), this critical threshold attains the maximum value of technological gap, the export option unambiguously enhances more the host country's welfare than greenfield investment entry mode. The rise of trade cost improves the local firms' profits, but reduces the aggregate outputs and then decreases the consumer surplus. In case of high trade cost, the gains from product surplus adequately compensate the losses from the consumer surplus. Therefore, export option generates the higher level of social welfare.

In case of weak technological gap, the competition in the host market is more intensive, three less dissimilar firms will globally produce more so that the consumer surplus increases under both entry modes. In fact, the sensibility of consumer surplus to the technological gap is different, which is given by:

$$\frac{\partial CS^E}{\partial s} < \frac{\partial CS^G}{\partial s} < 0$$

A reduction of the technological gap improves both CS^E and CS^G , furthermore, CS^E is more sensitive to the shrink of gap. On the other hand, there is a same extent of rise in terms of host country's producer surplus. Thus, the export entry mode could generate more aggregate surplus.

Welfare under greenfield investment credible threat

Under greenfield investment credible threat, the welfare level of the host country W^j with $j = \{E, G, M\}$ are compared. It is easy to find that, for all values of $s \in (0, \bar{s}]$, $t \in (0, \bar{t}]$ and $\theta \in [0, 1]$

$$\max\{W_{G,L}^M, W_{G,H}^M\} < \max\{W^G, W^E\}$$

Cross border M&A is never the most welfare-enhancing entry strategy under greenfield investment credible threat. Accordingly, the foreign firm's preferred M&A project is blocked by government. The foreign firm decides not to enter the host market in the context of export strategy improving the most welfare, whereas it could abandon the M&A plan and choose greenfield investment under the circumstance that greenfield investment enhances the most welfare.

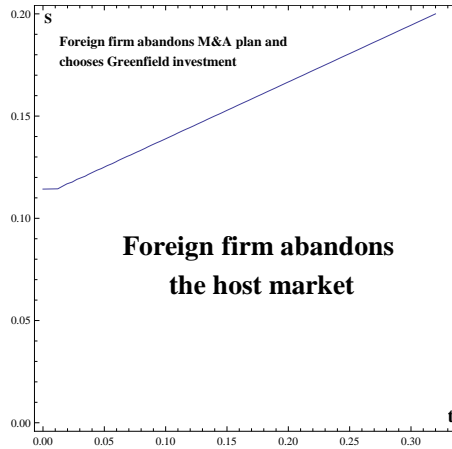


Figure 2.6. Foreign firm's decision with government supervision under G credible threat

On the basis of equilibrium welfare ranking, cross border M&A is never the most welfare-improving access strategy. The hierarchy amongst three alternative entry modes in terms of welfare hence reduces to the greenfield FDI-export comparison which refers to Figure 2.5 and 2.6. Under greenfield investment credible threat, even government blocks the M&A project, the foreign firm could reorient towards greenfield FDI when greenfield investment improves the most welfare. Both the government's authorization and the foreign firm's preference (because greenfield investment is more profitable than export) urge foreign firm to choose greenfield FDI; otherwise, the foreign firm has to decide not to serve the host market because of the conflict between private incentive and government's intention.

Welfare under export credible threat

Under export credible threat, the complexity of the solutions referring to social welfare makes it difficult to perform analytical comparisons. Therefore, in this subsection, we assume discrete values for the ability of integration parameter θ . This enables us to gain insights into the qualitative features of the optimal entry mode in terms of social welfare.

The ability of integration parameter θ is restricted to values from the set

$\{0, \frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\}$. By this assumption, it is possible to investigate the extreme cases of “no” integration ($\theta = 0$) and “maximum” integration ability ($\theta = 1$), and also to consider the cases of “small”, “medium”, and “large” integration ability (see **Appendix B.2**). Each figure represents combinations of trade cost (horizontal axis) and technological gap (vertical axis).

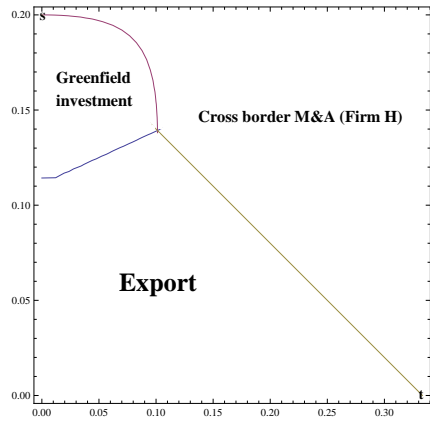


Figure 2.7. No integration ability ($\theta = 0$)

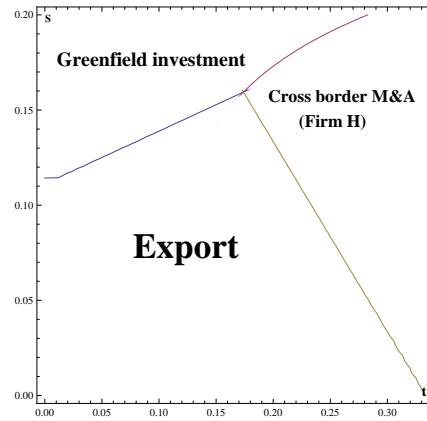


Figure 2.8. Small (or large) integration ability ($\theta = \frac{1}{4}$ or $\frac{3}{4}$)

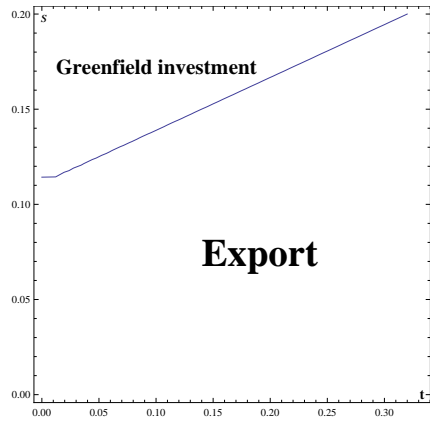


Figure 2.9. Medium integration ability ($\theta = \frac{1}{2}$)

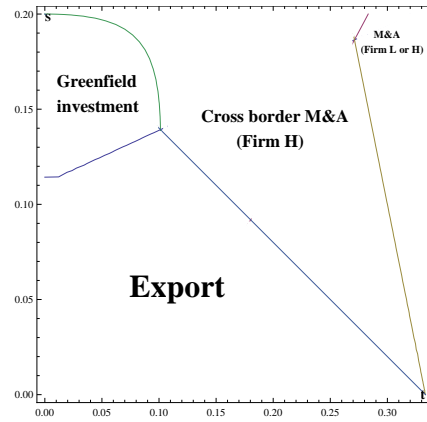


Figure 2.10. Maximum integration ability ($\theta = 1$)

The figures show clear trends. Beginning with Figure 2.7, when the integration ability is minimum¹⁷, we find that in *Cross border M&A* zone, M&A of firm *H* can more effectively improve the social welfare compared to other entry modes.

¹⁷Cross border M&A can not change the acquired firm for the better, reduce its marginal cost.

The reason behind this is shown as follow: When the foreign firm acquires the local firm H ¹⁸, the profit of outsider (firm L) reaches to the highest level, and it results in the rise of producer surplus. Moreover this rise of producer surplus compensates decrease of consumer surplus caused by the low competition intensity.

Obviously, following a decrease of trade cost, there is no change on consumer and producer surplus in greenfield investment option, but the producer surplus within cross border M&A option will decrease, because the payment for purchasing target firm depends on the trade cost. Thus, the welfare in M&A option could be less than the one in greenfield investment option when the trade cost attains a certain level. If the technological gap is weak, competing firms will be less heterogeneous, the level of aggregate outputs will be higher, and it will generate more consumer surplus. However, the magnitude of this increase is not identical, the consumer surplus in export option increases more rapidly following a decrease of technological gap; furthermore, the trade cost abatement leads to the fall of acquisition price which generates the decrease of producer surplus in the host country. Therefore, it is shown that the export entry mode gives rise to the highest level of social welfare in *Export* zone.

Based on the **Appendix B.2**, it is straightforward that

$$\frac{\partial W_{E,H}^M}{\partial \theta} = \frac{s^2(64\theta - 32)}{48}$$

$$W_{E,H}^M(\theta = 0) > W_{E,H}^M(\theta = \frac{1}{4} \text{ or } \frac{3}{4})$$

Consequently, on the one hand, the pattern for the “small” integration ability is the same to the one for “large” integration ability; on the other hand, the surface of zone, where cross border M&A entry mode is better off, diminishes. Whereas, the surface of both Export and Greenfield investment zones enlarge (Figure 2.8).

In Figure 2.9 where there is a “medium” integration ability ($\theta = \frac{1}{2}$), *Cross border M&A* zone disappears. This is also the case in which the acquisition of

¹⁸ $W_{E,H}^M$ is always higher than $W_{E,L}^M$ regardless of integration ability (θ), trade cost (t) and technological gap (s). See *Appendix B.1*.

local firm leads to the lowest level of welfare among all aforementioned degree of integration ability. Due to the disappear of M&A zone, the pattern is consistent with the Figure 2.5 in which we compare just the welfare in export option to that in greenfield investment option.

When the integration ability is maximum, the productivity of newly acquired entity is the same as the multinational firm's. Figure 2.10 reveals that not only the acquisition of firm H but also the purchase of firm L are better off. This outcome highlights the distinctness between greenfield investment credible threat and export credible threat. It is because the local firm's expected profit is higher under export credible threat, this gives rise to the higher acquisition price which positively acts on aggregate profits in the host country, indirectly improves the social welfare of host country. Specially, when export threat (trade cost) is strong, the acquisition of high-productivity firm can also be better off.

We now combine the foreign firm's preferred entry mode shown in Figure 2.3 with the government judgment (which regards the host country's welfare as yardstick). The following graphics (Figure 2.11, 2.12, 2.13, 2.14 and 2.15) permit us to analyze the interaction between the foreign firm and the host government.

Figure 2.11 is divided into different regions which reveal the possible combination of foreign firm's incentive and active government's intention. As shown in Figure 2.3, in the absence of integration ability ($\theta = 0$), foreign firm has always interest to acquire firm L , thereupon it notifies "Acquisition of firm L " project to government. Based on the equilibrium welfare (shown in Figure 2.7), the government approves the entry strategy enhancing the most welfare and prevents the other entry modes. For instance, in region A_1 , since the greenfield investment generates the highest level of welfare, the government blocks the M&A of firm L , the foreign firm is finally obliged to abandon the entry plan and decides not to serve the host market. In region A_2 , export is welfare dominant entry mode, notice also that export is the credible and viable entry mode here, therefore, the host government authorizes the export entry mode and persuades the foreign firm to choose export as entry fashion. In region A_3 , it is cross border M&A of firm H

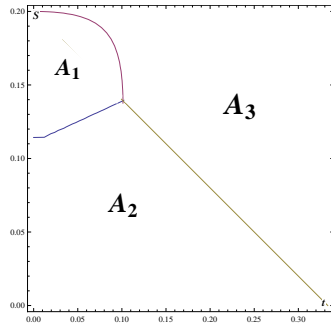


Figure 2.11. Export credible threat with $\theta = 0$

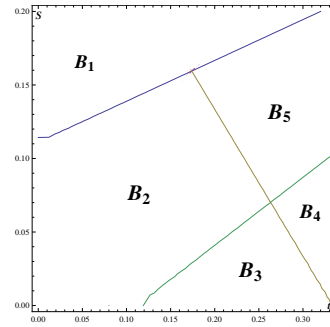


Figure 2.12. Export credible threat with $\theta = \frac{1}{4}$

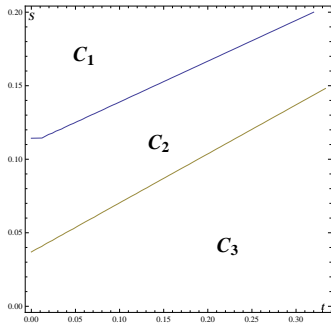


Figure 2.13. Export credible threat with $\theta = \frac{1}{2}$

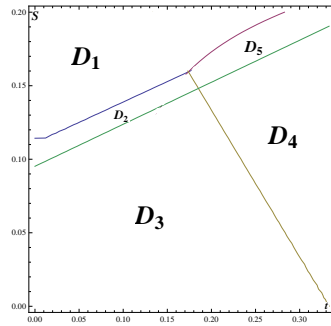


Figure 2.14. Export credible threat with $\theta = \frac{3}{4}$

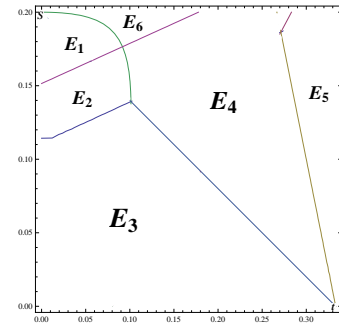


Figure 2.15. Export credible threat with $\theta = 1$

that improves the most host welfare, thus the project of “Acquisition of firm L ” is prohibited, the foreign firm has to give up.

In order to interpret these graphics more clearly, we construct the tables which embody “Foreign firm’s preference”, “Host government’s judgment” and the final “Entry mode”.

The insights from these tables can be summarized as follows: under export credible threat 1). If the host government judgement is taken into account, the foreign firm has no chance to adopt the cross border M&A strategy to enter the host market when there is “no” integration or “medium” integration measures. 2). The host government blocks the “Acquisition of high-productivity firm” project in any case, but it authorizes the “Acquisition of low-productivity firm” plan under certain circumstance. This M&A agreement processus highlights the unanimity

Export credible threat with $\theta = 0$			
Region	Foreign firm's preference	Host government's judgment	Entry mode
A_1	M&A (firm L)	Greenfield investment	Abandon
A_2	M&A (firm L)	Export	Export
A_3	M&A (firm L)	Cross border M&A (firm H)	Abandon

Export credible threat with $\theta = \frac{1}{4}$			
Region	Foreign firm's preference	Host government's judgment	Entry mode
B_1	M&A (firm L)	Greenfield investment	Abandon
B_2	M&A (firm L)	Export	Export
B_3	M&A (firm H)	Export	Export
B_4	M&A (firm H)	Cross border M&A (firm H)	M&A(firm H)
B_5	M&A (firm L)	Cross border M&A (firm H)	Abandon

Export credible threat with $\theta = \frac{1}{2}$			
Region	Foreign firm's preference	Host government's judgment	Entry mode
C_1	M&A (firm L)	Greenfield investment	Abandon
C_2	M&A (firm L)	Export	Export
C_3	M&A (firm H)	Export	Export

Export credible threat with $\theta = \frac{3}{4}$			
Region	Foreign firm's preference	Host government's judgment	Entry mode
D_1	M&A (firm L)	Greenfield investment	Abandon
D_2	M&A (firm L)	Export	Export
D_3	M&A (firm H)	Export	Export
D_4	M&A (firm H)	Cross border M&A (firm H)	M&A(firm H)
D_5	M&A (firm L)	Cross border M&A (firm H)	Abandon

Export credible threat with $\theta = 1$			
Region	Foreign firm's preference	Host government's judgment	Entry mode
E_1	M&A (firm L)	Greenfield investment	Abandon
E_2	M&A (firm H)	Greenfield investment	Abandon
E_3	M&A (firm H)	Export	Export
E_4	M&A (firm H)	Cross border M&A (firm H)	M&A(firm H)
E_5	M&A (firm H)	Cross border M&A (H or L)	M&A(firm H)
E_6	M&A (firm L)	Cross border M&A (firm H)	Abandon

between private incentive and collective intention, but eliminates the possibility to select the target firms. 3). Under the precondition that export is more profitable than greenfield investment, the conflict between foreign firm's preference and host government's decision induces the foreign firm to give up or to reorient towards export manner.

2.5 Concluding remarks

The choice of foreign entry mode is one of the core topics in international trade research (Werner, 2002), with many studies examining the *ex ante* determinants or the *ex post* performance implications of a firm's choice among certain modes. This paper draws on the traditions of both industrial organization and international trade theories. By developing a simple international oligopoly model, we provide a game-theoretic approach to explaining FDI and export activities, analyze both the "entry mode choice" and "target firm selection" decisions. Furthermore, the issue of foreign firm's preference and host government's judgment is tracked.

A main result of our analysis is that a foreign firm technologically advantaged has a stronger incentive to choose cross border M&A, rather than greenfield investment or export, moreover, it prefers acquiring the low-productivity firm when the integration ability is strong and the technological gap is sufficiently small; otherwise it prefers high-productivity one, under the precondition that greenfield investment is more profitable than export. If the export entry mode is viable, the variation of trade cost will alter the choice of target firm through the influence of acquisition price. The higher the trade cost is, the more likely foreign firm purchases low-technology firm. Our analysis has also highlighted the ambiguity between the foreign firm's preference and the government's judgment under greenfield investment threat, and the unanimity under export threat in certain situations. This private-collective conflict may be fruitful to inform government policies toward international trade.

There are certainly a number of interesting issues related to this framework,

that are not explored in the present paper. For instance, what will be the optimal entry mode, if firms produce differentiated goods? Whether the main findings hold true in other competition fashions (*e.g.*, Bertrand, Stackelberg)? How the results change if the trade cost here refers to the tariff designed by government? Among three alternative entry options, which one the foreign firm, facing unknown quality of its potential target, will choose? All these research questions will be studied in the future.

Part II

Collusion and Delegation under R&D spillovers

R&D Appropriability and Products Substitutability

Abstract: *We consider a two-stage game where firms with differentiated products firstly commit to cost-reducing R&D and then compete on the product market in a Cournot fashion. At each stage, firms can either coordinate their decisions or adopt non-cooperative strategy (Full Competition, Full Collusion and Semi-collusion regimes). The key feature of this model is to consider that the extent of product substitutability determines the ability of a firm to appropriate the R&D effort. Moreover, this ability is accurately adjusted by the measure of the sensibility of spillovers relative to product differentiation (concave or convex relationship). We find that cooperation in downstream stage always leads to higher R&D effort when the relationship between spillovers and product differentiation is concave. Under concavity condition, firms colluding in R&D regardless of their production strategy always yield more profit and generate more social welfare than firms colluding in output (independently of R&D strategy). When products are close substitutes, full collusion is a welfare-enhancing regime. Concerning the collusion stability, we demonstrate that partial collusion is more sustainable than full collusion.*

3.1 Introduction

It is well known that spillovers create a conflict between private and social incentives to exert R&D efforts. When R&D is a cost-reducing activity, the inability to fully appropriate all the gains from its own R&D effort intensifies the product market rivalry, because the R&D effort exerted by one firm may benefit the rival at no cost *via* spillover effect (Amir, 2000).

Within a game where firms are firstly engaged in costly research efforts in order to adopt a lower-cost technology and then compete in a Cournot fashion with homogeneous products, d'Aspremont and Jacquemin (1988) (henceforth "AJ") show that firms invest more under R&D cooperation than under R&D competition for sufficiently high spillover effects (full competition *versus* full cooperation). Kamien, Muller and Zhang (1992) (henceforth "KMZ") extend the AJ model to a more general framework with product differentiation and allow firms to participate in a research joint venture (RJV). They show that firms should be encouraged to form a RJV only if they coordinate their R&D decisions while maintaining competition for sales. Concerning the welfare effects of cooperative R&D with spillovers, cooperation raises social welfare when the spillover is high (Suzumura, 1992).

The model we propose departs from the literature in the sense where we consider that the ability of a firm to appropriate R&D efforts of its rival is largely determined by the degree of product substitutability, and accurately adjusted by the measure of the sensibility of spillovers relative to product differentiation, in other words "technological proximity". We aim to examine the circumstances under which firms choose to spend on high R&D efforts when the benefit that a firm can receive from their rivals' efforts in R&D is partially affected by the degree of product differentiation. On the one hand, when differentiation increases, the price of the product sold by the firm is less sensitive to the production level of its rival and this effect contributes to relaxing the intensity of competition. On the other hand, when products are more differentiated, the technological spillovers decrease, and the reduction in its own marginal cost due to a transfer of R&D effort from the competing firm becomes lower.

Several explanations can be provided in order to justify the “closer relationship” between R&D spillover and product differentiation. First, when products are close substitutes, R&D efforts are less firm-specific and a firm can more easily benefit from the discovery of a more efficient production technique resulting from rival’s R&D effort. In other words, the public good aspect of R&D is emphasized when firms evolve in an environment where products are homogeneous. Second, the exchange of technological information between engineers of competing firms is recognized as an important source of R&D spillovers (conferences, meeting . . .) (Severinov, 2001). For instance, Schrader (1991) empirically examines informal technology transfers and observes that 85% of technical managers have been asked for specific technical information and only 2% had never provided the requested information. It is natural to consider that the dissemination of technological knowledge across competing firms is strong when the products are less differentiated. Furthermore, the above-mentioned “closer relationship” is divided into two categories: *concave relationship* where firms adopt analogous technologies (*e.g.* the similar smart phones produced by Apple, Blackberry, Nokia . . .), *convex relationship* where firms adopt different technologies (*e.g.* Electricity is homogeneous good, but can be produced by different technologies: solar panels, wind turbines, *etc*).

In address models, the distance between firms determines the degree of product differentiation. By considering that R&D spillover depends negatively on firms’ product location, it is shown that R&D effort is positively associated with the differentiation of products¹ (Piga and Poyago-Theotoky, 2005; Dey and Fu, 2009). However, they do not address the issue of cooperative behavior between firms in their models.

Within this framework, we consider a two-stage game where firms with heterogeneous products competing in a Cournot fashion, engage in upstream R&D and downstream production. At each stage, the competing firms can either coordinate

¹The greater the distance between firms, the more differentiated the firms’ products, the less the R&D spillover.

their decisions or adopt non-cooperative strategy. We compare the Sub-game Perfect Nash Equilibrium (henceforth “SPNE”) emerging in four alternative scenarios such as Full Competition, Semi-collusion in Production², Semi-collusion in R&D³ and Full Collusion⁴.

KMZ (1992) claim that the R&D investment by firms engaged in Semi-collusion in R&D regime is unambiguously greater than that in Full Competition regime irrespective of spillovers. We demonstrate that which regime generates more R&D effort in equilibrium depends upon both the degree of product differentiation and the sensibility parameter to differentiation (technological proximity). If we restrict our attention to the concave relationship between product differentiation and R&D spillover, the ranking of R&D efforts is unalterable and independent of the differentiation degree, competition at the upstream stage depress R&D investment. Firms colluding in R&D regardless of their production strategy always yield more profit and generate more social welfare than firms colluding in output independently of R&D strategy. When products are close substitutes, the synergy effects prevail over the anti-competitive effects due to high spillovers, Full Collusion becomes a welfare-enhancing regime. Within the repeated game, we find that partial collusion is more sustainable than full collusion. Furthermore, R&D cooperation stabilizes the collusion when products are sufficiently differentiated and the technologies are comparatively removed.

The rest of this chapter is organized as follows. Section 3.2 presents the model and solves the subgame perfect equilibrium in four alternative regimes. We compare R&D effort, profit, consumer surplus and social welfare according to firms’ behavior (competitive or collusive) in section 3.3. Section 3.4 proceeds the collusion stability analysis and section 3.5 concludes this chapter.

²It is also called “Production Cartel”, see Brod and Shivakumar (1999).

³R&D Cartel.

⁴The Full Collusion regime could also be considered as horizontal merger.

3.2 The Model

Hypothesis

Consider two firms producing imperfectly substitutable goods. The representative consumer has a quasi-linear utility function $U(q_i, q_j) = a(q_i + q_j) - \frac{1}{2}(q_i^2 + q_j^2 + 2\gamma q_i q_j) + I$, where “ q_i ” is the output of firm i ; “ a ” is a constant which is assumed to be sufficiently large so that all firms produce positive amounts in equilibrium; “ I ” stands for the numeraire good, and it is assumed to be zero for simplicity. The parameter “ γ ” measures the substitutability⁵ between the products. The utility function generates the following inverse demand function (p_i) faced by firm i :

$$p_i(q_i, q_j) = a - q_i - \gamma q_j$$

The production technology exhibits a constant marginal cost “ c ” which can be reduced by investing in R&D. Due to spillovers, the R&D effort not only leads to a decrease in its own marginal cost but also reduces the marginal cost of the rival firm. Given the R&D effort x_j of firm j ($j = 1, 2$ and $i \neq j$), firm i ’s effective marginal cost is $C_i(x_i, x_j) = c - x_i - \beta x_j$. The R&D cost is assumed to be quadratic ($\frac{1}{2}x_i^2$), which reflects the decreasing returns to R&D effort.

The individual profit of firm i is defined by

$$\pi_i = \left(p_i(q_i, q_j) - C_i(x_i, x_j) \right) q_i - \frac{1}{2} x_i^2$$

with $i \neq j$; $i, j = 1, 2$

The social welfare is the sum of producer surplus (denoted by PS) and consumer surplus (denoted by CS):

$$W = PS + CS$$

where $PS = \pi_i + \pi_j$; $CS = U - p_i q_i - p_j q_j$

⁵If $\gamma = 0$, firms’ products are not substitutable and each firm acts as a monopolist; if $\gamma = 1$, products are homogeneous.

The key feature of the model is to consider that the extent of product substitutability (γ) determines the ability of a firm to appropriate the R&D effort of its rival. When products are less differentiated, competing firms share closer technological spaces, and one firm can benefit more from the rival's effort. We assume that the relationship between the spillover parameter (β) and the degree of product differentiation (γ) is described by:

$$\beta(\gamma, h) = \gamma^h \quad \text{with } h > 0, \gamma \in [0, 1]^6$$

We have $\frac{\partial \beta}{\partial \gamma} > 0$ and $\frac{\partial \beta}{\partial h} < 0$.

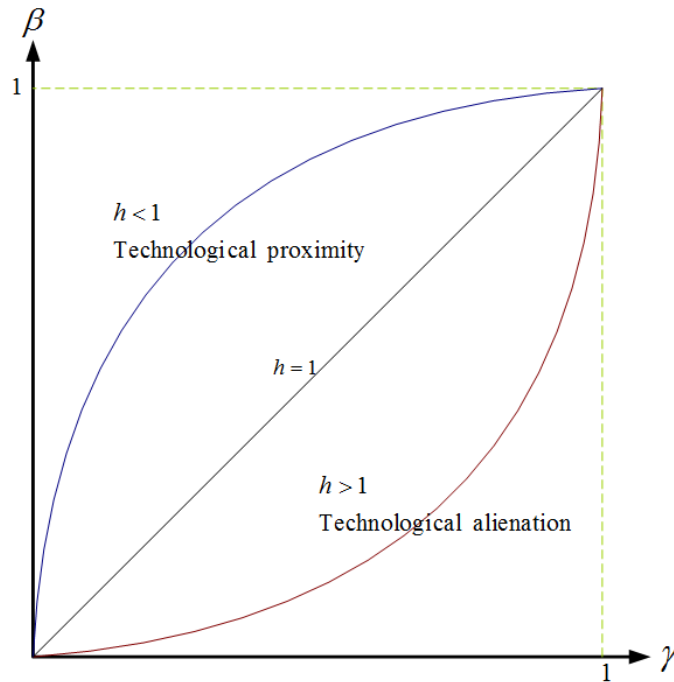


Figure 3.1. R&D spillovers and product differentiation

The parameter “ h ” determines both the sensibility of the R&D spillover to the

⁶When products are perfect substitutes, the spillover obviously equals to one and the game can not be solved. See AJ (1988).

degree of product differentiation, in other words *Technological proximity*⁷, and the level of spillover for a given value of differentiation (see Figure 3.1). We assume $h \in [\frac{1}{2}, \frac{3}{2}]$ in order to ensure an interior equilibrium of the game. The range of h permits us to touch upon the issue of concavity ($h < 1$) and convexity ($h > 1$). Since the derivative of β with respect to h is negative, we firstly incur that, for any given value of γ , the concave relationship implies a spillover effect greater to the one obtained with a convex relationship. In order to combine the extent of spillover with the upstream collusion, one could imagine that cooperation at the R&D stage corresponds to low value of “ h ” ($h < 1$). Secondly, under concavity condition, the more differentiated are the products, the more sensitive to γ is R&D spillover. Thirdly, from the perspective of *technological proximity*, the concavity refers to the situations where firms adopt analogous technologies. Fourthly, one can imagine that the concavity ($h < 1$) corresponds to industries that are geographically concentrated and that rely upon sources of basic scientific knowledge in the cluster⁸ benefit most from the exchange of knowledge and technology. By contrast, under convexity condition, the more differentiated are the products, the less sensitive R&D spillover with respect to γ ; the convexity delineates the situations where firms adopt different technologies.

We consider a two-stage game where firms act simultaneously at each stage. Firms select a strategic action (R&D effort) at the first stage anticipating correctly its impact at the second stage. The two competing firms can either coordinate their decisions or adopt non-cooperative strategy at each stage. When firms collude in one dimension (R&D or quantity) and compete in another one, such behavior is called *semi-collusion* (Fershtman and Gandal, 1994). We compare the SPNE emerging in four alternative scenarios (Table 3.1) such as Full Competition, Semi-collusion in Production, Semi-collusion in R&D and Full Collusion.

⁷From the perspective of *technological proximity*, it is straightforward that the more technologies are analogous, the greater spillover, for a given level of product differentiation.

⁸See more in Audretsch and Feldman (1996), Baptista and Swann (1988).

4 alternative scenarios	Two-stage game	
	First stage (R&D)	Seconde stage (production)
Full Competition (regime F)	Firms compete in R&D; each firm decides its own R&D level given R&D efforts of the other firm	Firms compete; each firm decides its own output in order to maximize the individual profit
Semi-collusion in Production (Production Cartel) (regime P)	Firms compete in R&D; each firm decides its own R&D level given R&D efforts of the other firm	Firms coordinate their production activities in order to maximize the joint profit
Semi-collusion in R&D (R&D Cartel) (regime R)	Firms coordinate their R&D activities in order to maximize the joint profit; cooperative behavior in R&D doesn't change the level of spillovers	Firms compete; each firm decides its own output in order to maximize the individual profit
Full Collusion (Horizontal Merger) (regime M)	Firms coordinate their R&D activities in order to maximize the joint profit; cooperative behavior in R&D doesn't change the level of spillovers	Firms coordinate their production activities in order to maximize the joint profit

Table 3.1. The four alternative scenarios

Subgame equilibrium in four regimes

Full Competition

We begin with regime F where there is no cooperation in both two stages. The subgame perfect equilibria are obtained by backward induction. Firm i chooses output q_i to maximize individual profit (π_i), and the firm i 's output as a function of R&D efforts is given by:

$$q_i^F(x_i^F, x_j^F) = \frac{A(2 - \gamma) + (2 - \gamma^{h+1})x_i^F + (2\gamma^h - \gamma)x_j^F}{4 - \gamma^2}$$

The sign of the derivative $\frac{\partial q_i^F(x_i^F, x_j^F)}{\partial x_i^F}$ is unambiguously positive, it demonstrates that the output of firm i increases with its own R&D effort. In contrast, concerning the sign of $\frac{\partial q_i^F(x_i^F, x_j^F)}{\partial x_j^F}$, we have

- $\frac{\partial q_i^F(x_i^F, x_j^F)}{\partial x_j^F} < 0$, if $h > 1 + \frac{\log(\frac{1}{2})}{\log \gamma}$

- $\frac{\partial q_i^F(x_i^F, x_j^F)}{\partial x_j^F} > 0$, otherwise

By substitution into the profit function, we can rewrite the profit function as $\pi_i^F(x_i^F, x_j^F)$. In the first stage, each firm chooses R&D effort independently to maximize the individual profit. The SPNE values of per-firm R&D effort, output, profit and social welfare are given by:

$$x^F = \frac{2A(2 - \gamma^{h+1})}{\Psi_F} \quad q^F = \frac{A(2 - \gamma)(2 + \gamma)}{\Psi_F} \quad (3.1)$$

$$\pi^F = \frac{A^2 \Xi_F}{\Psi_F^2} \quad W^F = \frac{A^2 \Omega_F}{\Psi_F^2} \quad (3.2)$$

with

$$A = a - c > 0$$

$$\Psi_F = (4\gamma + 8 - \gamma^3 - 2\gamma^2) + 2(\gamma^{2h+1} + \gamma^{h+1} - 2\gamma^h - 2) > 0$$

$$\Xi_F = (\gamma^2 - 4)^2 - 2(\gamma^{h+1} - 2)^2 > 0$$

$$\Omega_F = (48 + 16\gamma - 24\gamma^2 - 8\gamma^3 + 3\gamma^4 + \gamma^5) - 4(\gamma^{h+1} - 2)^2 > 0$$

Semi-collusion in Production

Semi-collusion in Production is denoted by P , firms choose their R&D efforts non-cooperatively but select their outputs cooperatively. Firm i 's output, as a function of R&D effort, can be expressed as:

$$q_i^P(x_i^P, x_j^P) = \frac{A(1 - \gamma) + (1 - \gamma^{h+1})x_i^P + (\gamma^h - \gamma)x_j^P}{2(1 - \gamma^2)}$$

The derivative $\frac{\partial q_i^P(x_i^P, x_j^P)}{\partial x_i^P}$ is always positive, and $\frac{\partial q_i^P(x_i^P, x_j^P)}{\partial x_j^P}$ is positive when $h < 1$ (R&D spillover is a *concave* function of product substitutability); negative while $h > 1$ (*convex* function).

The SPNE:

$$x^P = \frac{A(2 - \gamma^{h+1} - \gamma)}{\Psi_P} \quad q^P = \frac{2A(1 - \gamma)}{\Psi_P} \quad (3.3)$$

$$\pi^P = \frac{A^2 \Xi_P}{2\Psi_P^2} \qquad W^P = \frac{A^2 \Omega_P}{\Psi_P^2} \qquad (3.4)$$

with

$$\begin{aligned} \Psi_P &= 4(1 - \gamma^2) + \gamma^h(2\gamma + \gamma^{h+1} - 2) + \gamma - 2 > 0 \\ \Xi_P &= 8(\gamma^3 - \gamma^2 - \gamma + 1) - (\gamma^{h+1} - 2)^2 + 4\gamma - \gamma^2 - 2\gamma^{h+2} > 0 \\ \Omega_P &= 12(\gamma^3 - \gamma^2 - \gamma + 1) - (\gamma^{h+1} - 2)^2 + 4\gamma - \gamma^2 - 2\gamma^{h+2} > 0 \end{aligned}$$

Semi-collusion in R&D

Firms coordinate their R&D investment in the R&D stage and then maintain competition in the production stage. This regime is abbreviated by R

$$x^R = \frac{2A(1 + \gamma^h)}{\Psi_R} \qquad q^R = \frac{A(2 + \gamma)}{\Psi_R} \qquad (3.5)$$

$$\pi^R = \frac{A^2}{\Psi_R} \qquad W^R = \frac{A^2 \Omega_R}{\Psi_R^3} \qquad (3.6)$$

with

$$\begin{aligned} \Psi_R &= (\gamma + 2)^2 - 2(\gamma^h + 1)^2 > 0 \\ \Omega_R &= (\gamma^5 + 11\gamma^4 + 46\gamma^3 + 86\gamma^2 + 64\gamma + 16) + 8(\gamma^{4h} + 4\gamma^{3h} + 6\gamma^{2h} + 4\gamma^h) \\ &\quad - (40\gamma^{2h} + 80\gamma^h + 2\gamma^{2h+3} + 96\gamma^{h+1} + 48\gamma^{2h+1} + 36\gamma^{h+2} + 18\gamma^{2h+2} + 4\gamma^{h+3}) \\ &> 0 \end{aligned}$$

Full Collusion (Horizontal Merger)

This scenario is regarded as the framework of multi-dimensional coordinations in which firms cooperate in both R&D and production stages. Since the products are imperfectly substitutable, Full Cooperation⁹ means that the firms maximize their joint profit in each stage. Despite the ostensibly widespread use of Full Collusion to exploit the complementarities in firm's R&D process, the formal literature on R&D has almost focus exclusively on research joint venture, whereby firms share

⁹The Full Collusion regime could also be considered as horizontal merger.

out technological knowledge ($\beta = 1$) while continuing to compete against each other in product market (see for instance Kamien et al., 1992).¹⁰

The equilibria of R&D effort, output, profit and welfare are given by

$$x^M = \frac{A(1 + \gamma^h)}{\Psi_M} \qquad q^M = \frac{A}{\Psi_M} \qquad (3.7)$$

$$\pi^M = \frac{A^2}{2\Psi_M^2} \qquad W^M = \frac{A^2\Omega_M}{\Psi_M^2} \qquad (3.8)$$

with

$$\Psi_M = 2(1 + \gamma) - (\gamma^h + 1)^2 > 0$$

$$\Omega_M = 3(1 + \gamma) - (\gamma^h + 1)^2 = \Psi_M + (1 + \gamma) > 0$$

In the following section, we will compare these four aforementioned regimes in terms of significative relevance such as R&D investment, profit, consumer surplus and social welfare.

3.3 Comparison of different regimes

R&D effort

We start with the comparison of R&D investment level in the above-mentioned regimes and address the question: which regime generates the highest equilibrium R&D effort?

¹⁰Kamien et al. (1992) provide a thorough analysis of RJV, contrasting the case of RJV Competition where firms pool R&D results but behave non-cooperatively at both stages, and RJV Cartelization (the pooling of R&D results with cooperative determination of R&D investment but competition in subsequent product market stage). Suzumura (1992) contains a closely related analysis. D'aspremont and Jacquemin (1988) do allow for merger under which firms pool R&D results and cooperate in both stage of the game. It is worth noting that there are the analysis of the converse case to RJV, where all firms compete in R&D stage but then collude in outputs, see Fershtman and Gandal (1994) and Brod and Shivakumar (1999).

In order to compare individual levels of R&D under different regimes, let us define the functions $f_k(\gamma, h)$, $g_k(\gamma, h)$ and $j_F(\gamma, h)$

$$\begin{aligned} f_k(\gamma, h) &= x^M(\gamma, h) - x^k(\gamma, h) & k &= \{F, P, R\} \\ g_k(\gamma, h) &= x^R(\gamma, h) - x^k(\gamma, h) & k &= \{F, P\} \\ j_F(\gamma, h) &= x^P(\gamma, h) - x^F(\gamma, h) \end{aligned}$$

We plot the curves $f_k(\gamma, h) = 0$, $g_k(\gamma, h) = 0$, $j_F(\gamma, h) = 0$ in γ and h space and this pattern implies the ranking of R&D efforts into five zones (Figure 3.2).

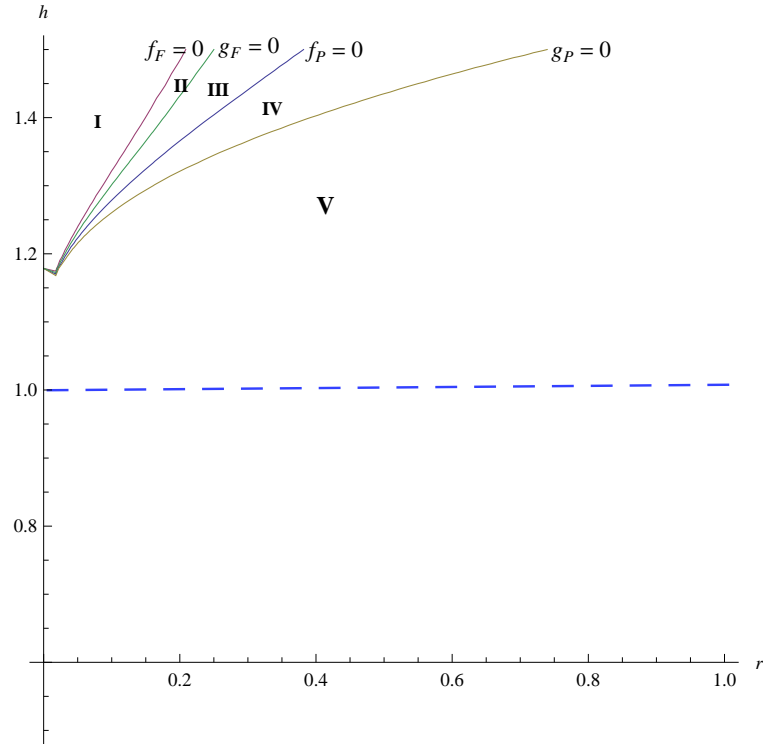


Figure 3.2. The ranking of R&D efforts

Result 5. *The equilibrium R&D efforts in different regimes are arranged in the following form:*

- $x^P > x^F > x^M > x^R$ (Zone I)
- $x^P > x^M > x^F > x^R$ (Zone II)

- $x^P > x^M > x^R > x^F$ (Zone III)
- $x^M > x^P > x^R > x^F$ (Zone IV)
- $x^M > x^R > x^P > x^F$ (Zone V)

Result 5 reveals that when firms have same behavior (cooperation or competition) in upstream R&D stage, firms allowed to cooperate in the product market always exert more R&D efforts in equilibrium compared to firms competing in downstream stage ($x^M > x^R$ and $x^P > x^F \forall \gamma, h$). As we know, R&D effort reduces the marginal cost and indirectly leads to a decrease in the products prices. When firms can collude in the second stage, they restrict their outputs for a given R&D effort and as a consequence the negative impact of R&D efforts on the product price is alleviated. Conversely, an intense product competition dissipates the benefits of R&D effort and therefore shrinks the incentive to invest in R&D. Output cooperation has a positive impact on R&D investment and then induces firms to undertake more R&D than they would under competition in the downstream stage. Moreover, if we restrict our attention to the case where the relationship between differentiation and spillover is concave, the ranking of R&D efforts ($x^M > x^R > x^P > x^F$) does not alter, and it is independent of the differentiation degree. It means that the Full Collusion participants spend more on R&D than Semi-collusion ones, under concave relationship.

For a given behavior at upstream stage, the output collusion reinforces the R&D effort. However, when the behavior at downstream stage is given, the R&D cooperation does not unambiguously increase research efforts. If we compare the regimes F and R (corresponding to the lowest level in R&D effort for each of the five different zones), we find that R&D cooperation could be detrimental to R&D effort in *Zone I* and *Zone II*, *i.e.* in cases of highly differentiated products and the sufficiently low level of spillovers (both high h and low γ). This finding is in sharp contrast with the existing literature, for instance, KMZ (1992) show that x^R is unambiguously greater than x^F without taking into account the substitutability-spillover relationship.

The striking outcome we find here is that R&D effort under regime P can be the largest (*Zones I, II and III*). It is different from the conventional wisdom that merged firms have more incentive to invest in R&D because they appropriate all the R&D efforts. The spillover effect constitutes a negative externality for the firm which spent on R&D effort (decrease in the rival's marginal cost). This externality is internalized when firms cooperate in the first stage (regime M) which leads to a lower level of R&D effort compared to competition in R&D (regime P) when the spillover effect is low (*Zones I, II and III*).

From the aggregate surplus point of view, the welfare performance of R&D investment in different scenarios can be gauged and compared with the First-Best welfare criteria (Suzumura, 1992). **Appendix C.1** provides the proof of the expression x^{FB} .

$$x^{FB} = \frac{A(1 + \gamma^h)}{(1 + \gamma) - (1 + \gamma^h)^2}$$

Obviously, x^{FB} is the significant standard accessing whether or not the R&D investment is efficient when the denominator $(1 + \gamma) - (1 + \gamma^h)^2$ is positive.

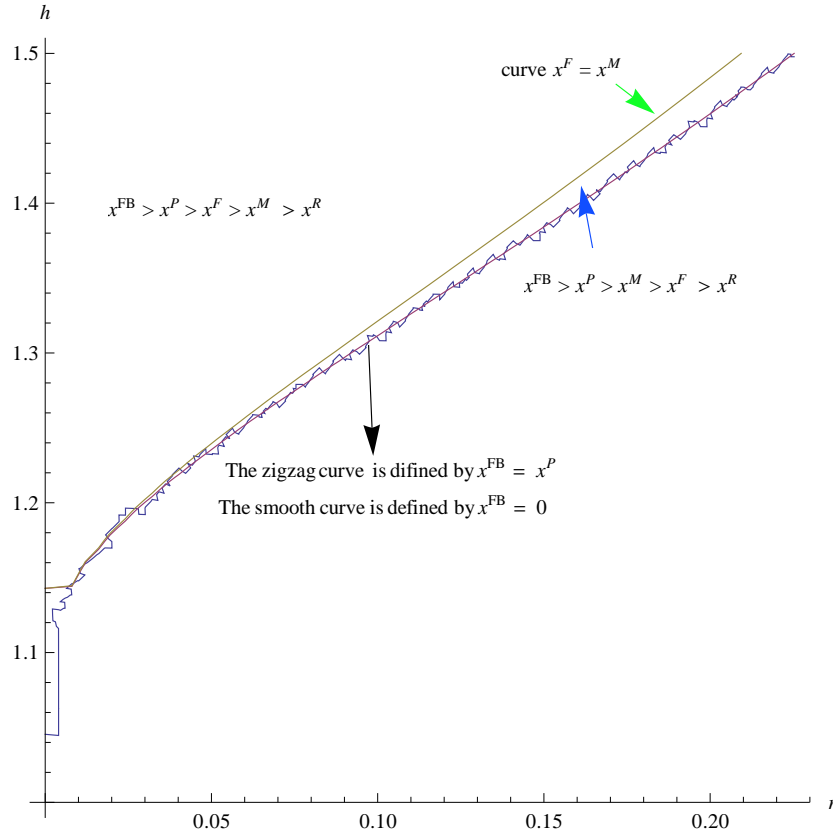


Figure 3.3. Socially first best R&D

In Figure 3.3, we plot the curves in $\gamma \in [0, \frac{1}{4}]$ and $h \in [1, \frac{3}{2}]$ space so as to zoom and emphasize the area $x^{FB} > 0$. The curve $x^{FB} = 0$ divides the patten into two parts and the left part represents $x^{FB} > 0$. Points to the left of the curve $x^{FB} = x^P$ define combinations of γ and h where $x^{FB} > x^P$. The curve $x^M = x^F$ separates the left segment($x^{FB} > 0$) into two arenas in which the hierarchies are different. Except for regime P , the Figure 3.3 sums up the following result:

Result 6. $x^{FB} > \max\{x^F, x^R, x^M\}$ in the segment where $x^{FB} > 0$

As demonstrated in AJ (1988) and Henriques (1990), the social optimum R&D effort is unambiguously greater than the equilibrium levels of R&D under the fully cooperative or noncooperative or mixed¹¹ game. We find the similar result when

¹¹Firms cooperate in R&D but remain noncooperative in output. This game corresponds to the Semi-collusion in R&D within our framework.

firms produce sufficiently heterogenous goods. It is worthwhile to note x^P could be higher than x^{FB} in a small or infinitesimal area where a higher level of R&D effort corresponds to a wasteful duplication without R&D externality effect.

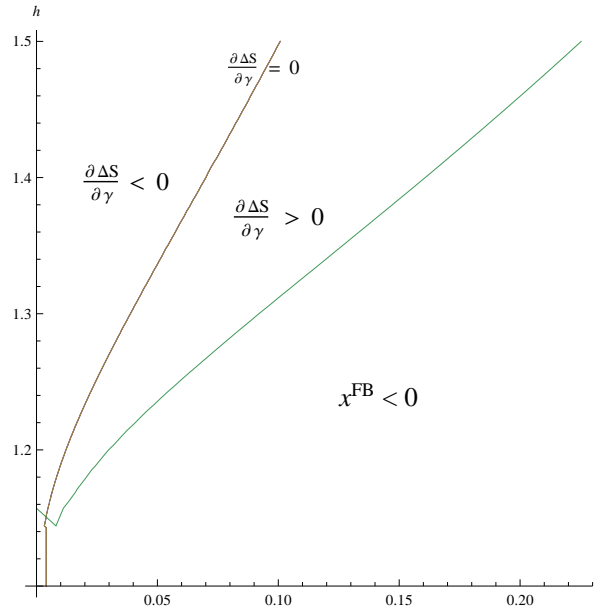


Figure 3.4. Welfare performance in R&D efforts of different regimes

Apart from regime P , let us define ΔS as the difference between the social optimum and the level of R&D effort in each scenario:

$$\Delta S = x^{FB} - x^S$$

$$\text{with } S = \{F, R, M\}$$

We attempt to delineate how the gap ΔS evolve following the variation of product differentiation. It is shown that the three curves $\frac{\partial \Delta S}{\partial \gamma} = 0$ with $S = \{F, R, M\}$ completely overlap. When products are sufficiently differentiated, an increase of γ gives rise to a reduction of the gap in R&D between social optimum and regime S ; otherwise when γ exceeds a lower bound (*cf.* Figure 3.4), this gap increases with product differentiation. Therefore, points on the curve $\frac{\partial \Delta S}{\partial \gamma} = 0$ minimizing the disparity are the closest to social optimum R&D effort.

Output and Consumer Surplus

Since we compare symmetric equilibria, output is considered as an index of consumer surplus ($CS^k = (1 + \gamma)(q^k)^2$ with $k = \{F, P, R, M\}$). We trace out the meaningful zones by plotting the following curves:

$$\begin{cases} R_k(\gamma, h) = q^M(\gamma, h) - q^k(\gamma, h) & \text{with } k = \{F, P, R\} \\ V_k(\gamma, h) = q^R(\gamma, h) - q^k(\gamma, h) & \text{with } k = \{F, P\} \\ Z_F(\gamma, h) = q^P(\gamma, h) - q^F(\gamma, h) \end{cases}$$

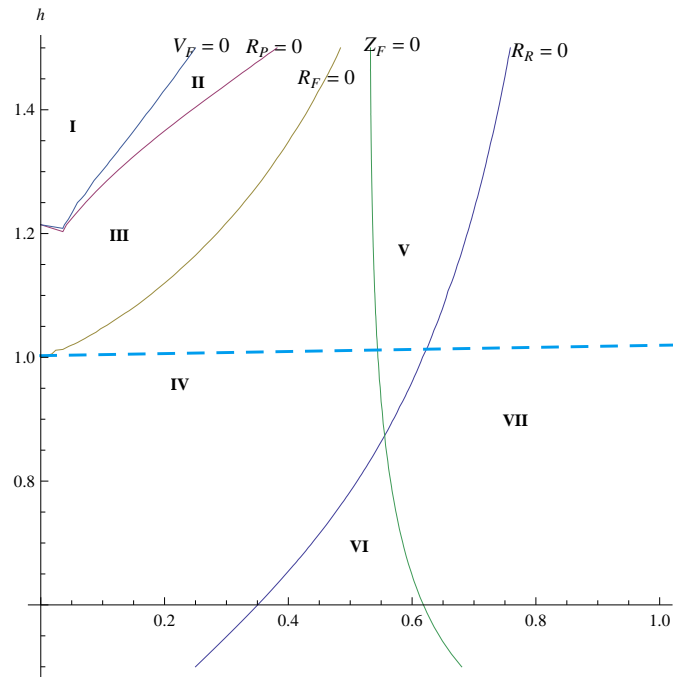


Figure 3.5. The output (consumer surplus) ranking

Result 7. *The individual output equilibrium in different regimes:*

- $q^F > q^R > q^P > q^M$ (Zone I)
- $q^R > q^F > q^P > q^M$ (Zone II)

- $q^R > q^F > q^M > q^P$ (Zone III)
- $q^R > q^M > q^F > q^P$ (Zone IV)
- $q^R > q^M > q^P > q^F$ (Zone V)
- $q^M > q^R > q^F > q^P$ (Zone VI)
- $q^M > q^R > q^P > q^F$ (Zone VII)

The relationship $q^R > q^P$ is always true for all γ and h . The intuition behind this result could stem from the variation of competition intensity¹². Under regime R , upstream collusion leads to much more fierce rivalry in non-cooperative output stage. Furthermore, since firms collude in output under regime P , the market becomes looser and the firms have more incentives to increase the prices by reducing output.

There is no stable hierarchy among output in different regimes. This is because the impact of R&D effort is complicated and exerts two conflicting effects on the output of rival firm. On the one hand, R&D effort is managed to induce the firm to expand output at expense of its rival by cutting down its own production cost. It is considered as the *substitutability effect* (an increase in its own output leads to a decrease in rival's output) which is greater, the more substitutable the products are. On the other hand, the R&D effort can reduce the rival firm's cost, thereby increase its rival firm's output. It is regarded as the *spillover effect* (boosting rival's output) which is greater the larger the spillover is. Since the spillover (β) positively depends on the degree of product differentiation, when products are more homogeneous, both substitutability effect and spillover effect enlarge. Whether the output (consumer surplus) increases depends on the interplay of these two conflicting effects. If the spillover effect prevails over the substitutability effect, under this circumstance, firms are motivated to expand output; otherwise, they prefer to shrink output.

According to Figure 3.5, it is clear that firms colluding in R&D produce more than firms competing on R&D when the relationship between the substitutability

¹²See Fershtman and Gandal (1994).

extent and the spillover level is concave ($h < 1$). And this result always holds true regardless of product differentiation. Under this circumstance that the leakage of know-how is relatively strong (concavity relationship), firms which cooperate on R&D are willing to spend more on R&D efforts (see Result 5), the marginal costs of both firms reduce so much that the spillover effect prevails over the substitutability effect and firms are motivated to expand output. The curve $V_F = 0$ is a watershed of the relationship between q^R and q^F which is consistent with the corollary shown in KMZ (1992)¹³.

We find that firms colluding in output produce less compared to the firms competing in production market when the goods are sufficiently differentiated (*Zone I, II, III*). Firstly, the downstream output cooperation spurs on the firms to increase the price and decrease the output; secondly, since the low value of γ leads to small spillovers, the R&D efforts exerted by firm i cannot sufficiently reduce its rival's marginal cost, this spillover effect is not strong enough to compensate the decrease in output due to production cooperation, therefore firms have to shrink output under this condition.

Each of the alternative regimes except Semi-collusion in Production, can yield the highest level of output for plausible parameter combinations. When firms produce sufficiently similar goods, the Full Collusion regime (in *Zone VI and VII*) ensures the highest level in output. This finding is in contrast with the traditional literature "the firms under Full Competition always produce more than the firms under Full Collusion scenarios¹⁴". The reason behind this is the differentiation-spillover relationship: low level of differentiation generates high spillover, on the other hand it induces firms under Full Collusion to spend more on R&D (See Result 5), accordingly the marginal cost of Full Collusion participants is sufficiently reduced, firms under Full Collusion have interest to expand their output. We also find the output level is the highest in regime R when the goods are sufficiently

¹³They demonstrate the price (output) in R&D cartelization is less (more) than the price in R&D competition if and only if $\gamma \leq 2\beta$.

¹⁴D'Aspremont and Jacquemin (1988) and Henriques (1990) demonstrate the level of output in noncooperative two-stage case is always higher than that in fully cooperative situation. In addition, they claim that the mixed game can generate more output than noncooperative two-stage game for large spillovers. These models base on the assumption of homogenous goods.

differentiated (*i.e.* Zone II,III,IV,V). Furthermore, if the sensibility parameter h is comparatively large, Full Competition generates the highest output level (Zone I). The reason of the instable relationship between q^R and q^M arises from the sensibility of output to R&D effort: In the symmetric equilibrium, the sensibility under regime R and M are respectively given by

$$\frac{\partial q^R}{\partial x^R} = \frac{2 - \gamma^{h+1} + 2\gamma^h - \gamma}{4 - \gamma^2} > 0$$

$$\frac{\partial q^M}{\partial x^M} = \frac{1 - \gamma^{h+1} + \gamma^h - \gamma}{2(1 - \gamma^2)} > 0$$

We find $\frac{\partial q^R}{\partial x^R} > \frac{\partial q^M}{\partial x^M}$, this inequality discloses that the output in regime R is more sensitive to R&D effort compared to the one in regime M , in addition, $x^M > x^R$ always holds true (Result 5). Indeed, q^M is larger than q^R in certain zones (*i.e.* Zone VI and VII).

Profit

According to Brod and Shivakumar (1999)¹⁵, the profit under Full Competition could be larger than the one under Semi-collusion in Production in some cases.

¹⁵In an one-stage game, cartels increase industry profits and exacerbate the consumer surplus. In a model where firms collude in production but compete in R&D, the cartel members may be worse off and consumers better off due to over-investment by firms eager to improve their position in the cartel. Brod and Shivakumar(1999) analyze a two-stage model and examine the effect of semi-collusion when the non-production activity is R&D. Firms choose their R&D effort in a first stage and output in a second stage. They shed light on the fact that in the presence of spillovers, firms and consumers could be both better off, peradventure both worse off, by a semi-collusive production cartel. We are attired by this fascinating outcome. Thereupon, we try to approach the in-depth analysis and to understand the driving forces of this result. We find however that the findings of BS (1999) are disputable. The incorrect Sub Game Perfect Equilibrium values of per-firm R&D effort, output and profit due to improper handling result in the inaccuracy of their main propositions. When the goods are sufficiently substitutable, the proposition 1 doesn't hold. In other words, there is no absolute predominance of production cartel in terms of R&D effort. Since the optimum equilibrium of cartel at the production stage could be negative for certain combination parameters (the degree of product differentiation and the level of spillovers), we find the region D depicted as "*Consumers prefer Production Cartel; firms prefer Competition*" could not always satisfy the conditions mentioned in proposition 2. In **Appendix C.2**, we focus upon their calculative errors, and show what the correct solution can be.

Result 8. *The equilibrium individual firm's profits are arranged:*

$$\begin{aligned} i) \quad & \pi^M > \max[\pi^P, \pi^R] > \min[\pi^P, \pi^R] > \pi^F \quad \forall \gamma, h \\ i.i) \quad & \pi^M > \pi^R > \pi^P > \pi^F \quad \forall \gamma \quad \text{if } h < 1 \end{aligned}$$

When the spillover depends on the product substitutability, the firm's profit in regime P always prevails over the one in regime F . This result is in contrast with BS (1999) who show that the profit under regime F could be higher than that under regime P . More generally, in line with semi-collusion literature (Matsui, 1989; Fershtman and Gandalf, 1994), we establish the possibility that R&D cartel is less profitable than Production cartel.

We reveal that the profit by means of cooperative behavior in two stages prevails over one-dimension cooperation profit which is higher than the profit earned by the firm in Full Competition. The only ranking which may be altered is the one between two types of semi-collusion. The alluring question is which type of semi-collusion (Production or R&D) will be more beneficial for firms.

Consider Δ as the difference of profit in the two semi-collusion scenarios:

$$\Delta = \pi^P - \pi^R$$

We examine the profit ranking with the same method used in previous subsection. Our result is illustrated in Figure 3.6. The interesting conclusion which emerges from this figure is that both two semi-collusions of different type possibly yields higher value.

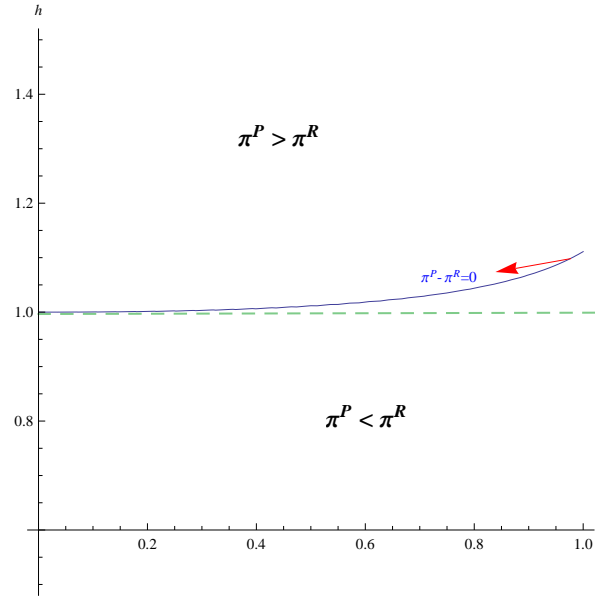


Figure 3.6. Two types of semi-collusion

Under concavity condition, firms colluding in R&D always yield more profit than firms colluding in output. The intuition of this result is the following: the distinctive advantage of regime R compared to regime P is that firms invest more in R&D with concave relationship (See Result 5), thereby firms are more competitive due to cost-saving by R&D effort; furthermore, Result 7 claims that firms in regime R produce more at all time than members of Semi-Collusion in Production. Despite the fact that more investment on R&D leads to more expenditures, firms in regime R prevail over the ones in P when $h < 1$ in terms of profit.

The inverse outcome $\pi^R < \pi^P$ could take place for some plausible γ under convexity condition. However, the implicit predominance $\pi^P > \pi^R$ could appear when h is approximately greater than the critical value which is equal to 1.12.

Social Welfare

In general, the welfare is damaged by collusion: in one-stage game, the collusion always harms the welfare; whereas in two-stage game where firms firstly select

R&D efforts, collusion reduces welfare if it occurs in each of the two stages¹⁶. We determine which regime is the most relevant with regard to aggregate surplus (Figure 3.7).

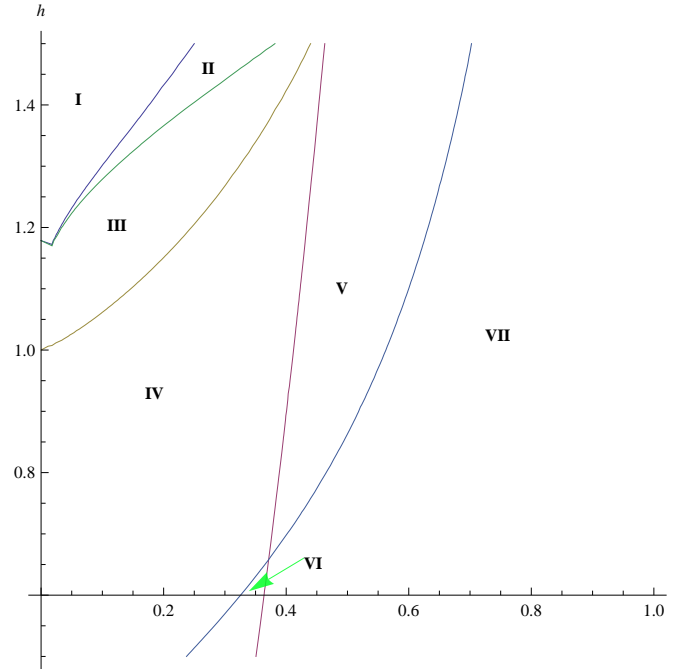


Figure 3.7. The welfare ranking

Result 9. *The social welfare ranking:*

- $W^F > W^R > W^P > W^M$ (Zone I)
- $W^R > W^F > W^P > W^M$ (Zone II)
- $W^R > W^F > W^M > W^P$ (Zone III)
- $W^R > W^M > W^F > W^P$ (Zone IV)
- $W^R > W^M > W^P > W^F$ (Zone V)
- $W^M > W^R > W^F > W^P$ (Zone VI)

¹⁶See d'Aspremont and Jacquemin (1988), Suzumura (1992).

- $W^M > W^R > W^P > W^F$ (Zone VII)

We highlight that the collusive behavior in both stages could enhance the welfare (*Zone VI, VII*). If we consider the equilibrium social welfare level in Full Competition regime as the criterion value, not only Full Collusion but also Semi-collusion could improve the welfare in some cases. For example, regime *R* is the welfare dominant regime when products are sufficiently differentiated. We also find under concavity condition, firms colluding in R&D regardless of their production strategy always enhance more social welfare than firms colluding in output independently of R&D strategy. Cooperation in production could lead to a decrease in social welfare under convexity condition.

Although the hierarchies in these zones are the same as the ones depicted in Result 7, it is clear that there are some points of dissimilarity, such as the location of the different zones and the size of zones. In virtue of this dissimilarity, the discussion on antitrust policy is unsealed. In what follows, we focus on the difference of consumer welfare standard and total welfare standard.

Merger control: Consumer welfare standard Vs Total welfare standard

On the basis of the previous result, we can conclude that society could benefit from not only the cooperative behavior in one dimension (Semi-collusion in R&D or in Production) but also from the merger. Therefore, all regimes can yield the highest level of welfare for plausible parameter combinations.

Nowadays, most countries have laws or regulations that require competition authorities to scrutinize horizontal mergers. These authorities normally do not examine whether a particular merger is likely to affect welfare because it substantially lessens competition (USA) or significantly impedes effective competition (European Union). The US or EU apply a consumer welfare criterion to mergers. Canada, Australia and New Zealand however consider a merger's effects on aggregate surplus and had a very explicit aggregate surplus standard (Motta, 2004).

Consequently, we make use of both total welfare standard and consumer welfare standard within our framework, in order to analyze the difference of these two above-mentioned criteria, to examine whether the merger prohibited under aggregate welfare standard can be authorized under consumer welfare standard and *vice versa*.

From the perspective of competition policy, we consider the regime Full Competition and Semi-collusion in R&D as benchmarks. The competition authorities authorize the merger satisfying the following condition in case of total welfare standard:

$$W^M > \max\{W^F, W^R\}$$

In case of consumer welfare standard:

$$CS^M > \max\{CS^F, CS^R\}$$

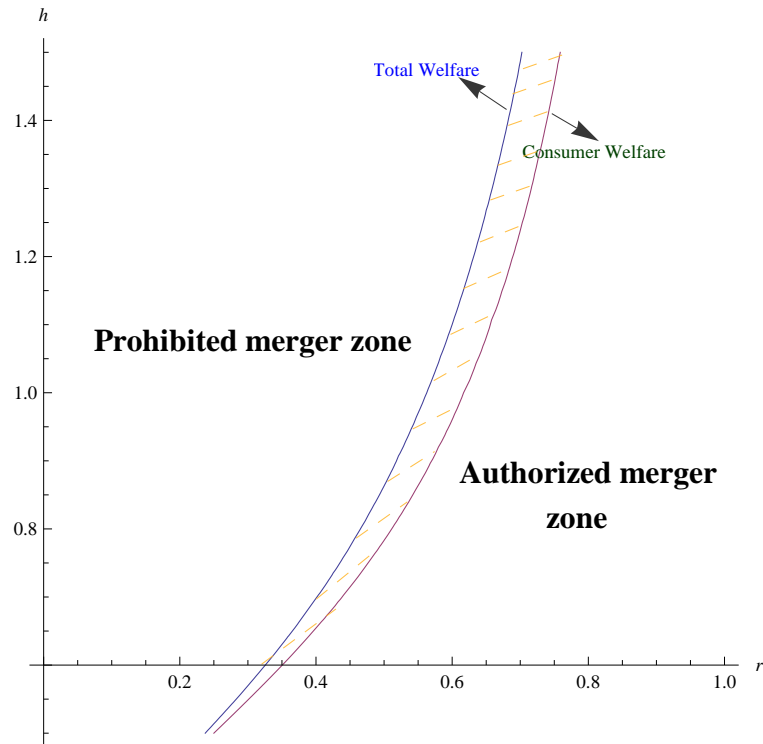


Figure 3.8. Total welfare standard Vs Consumer welfare standard

In Figure 3.8, on the right side of curve *Consumer Welfare*, the merger regime is accepted by consumer welfare standard. Total welfare standard authorizes the merger regime when the beach of parameter combination locates to the right of the curve named *Total Welfare*. It is straightforward that there is the gap (dashed area) between two mentioned curves which sheds light on the looseness of total welfare standard and preciseness of consumer surplus standard. Due to the prohibition by competition authorities, in the left side, the firms have to lean to the less attracting regimes which yield less profit compared to merger one. Therefore, the firms prefer the Semi-collusion in R&D (semi-collusion¹⁷) in prohibited merger zone ($\pi^R > \pi^F$).

3.4 Collusion stability analysis: repeated game

In this section, we consider an infinite repeated game to illustrate the robustness of partial or full collusion. Consider now the incentive for firm i to deviate if neither firm has deviated in the past. The payoff for firm i if it deviates will be $\pi_i^{T,D}$. Note that the superscript T represents the “Type” of collusion, namely $T = \{R, P, M\}$, and the superscript D means the deviation. However, in subsequent periods the competitor will punish i by reverting to its Full Competition (regime F) R&D effort and output, so that firms’ profits equal to π^F (see Eq. (3.1)) in every period after deviation. “ δ ” denotes the common discount factor ($0 < \delta < 1$). Discounting occurs between periods, but not between the two stages of a period. The present value from deviating at the current period is:

$$V_i^D = \pi_i^{T,D} + \frac{\delta \pi^F}{1 - \delta} \quad (3.9)$$

The present value of deviating equals the profits from deviating today plus the discounted value of regime F ’s profits in every period thereafter, $\frac{\pi^F}{1-\delta}$, discounted back from the next period, $\frac{\delta \pi^F}{1-\delta}$.

¹⁷Note that in reality, the Production Cartel is prohibited. Thus, we exclude it in antitrust control analysis.

The payoff from continuing to cooperate is the present value of collusive profits forever. Let $\pi_i^{T,\star}$ denote the profits of firm i if firms collude, then

$$V_i^\star = \frac{\pi_i^{T,\star}}{1 - \delta} \quad (3.10)$$

Firm i will not find it profitable to deviate if

$$\frac{\pi_i^{T,\star}}{1 - \delta} \geq \pi_i^{T,D} + \frac{\delta \pi^F}{1 - \delta} \quad (3.11)$$

or

$$\delta \geq \frac{\pi_i^{T,D} - \pi_i^{T,\star}}{\pi_i^{T,D} - \pi^F} = \bar{\delta}^T \quad (3.12)$$

If the discount factor exceeds the threshold $\bar{\delta}^T$, the *grim* trigger strategies will sustain a collusive agreement, and reversely while $\delta < \bar{\delta}^T$. The critical value of the discount factor equals the ratio of the gain today from renegeing or deviating (the numerator) and the loss tomorrow of reversion back to the non-collusive equilibrium (the denominator). $\bar{\delta}^T$ is decreasing in collusive profits ($\pi_i^{T,\star}$) and increasing in both non-collusive profits (π^F) and the profitability of defection ($\pi_i^{T,D}$). The less profitable collusion, the less harsh the punishment, and the greater the profits from defection, the greater the discount factor must be in order for firm i not to have an incentive to deviate.

By separately analyzing the aforementioned different types of collusion (R , P and M), we obtain the critical values of discount factor for each type. The process of achieving the deviating firm's payoff $\pi_i^{T,D}$ and the expressions of $\bar{\delta}^R$, $\bar{\delta}^P$ and $\bar{\delta}^M$ are respectively shown in **Appendix C.3** and **C.4**.

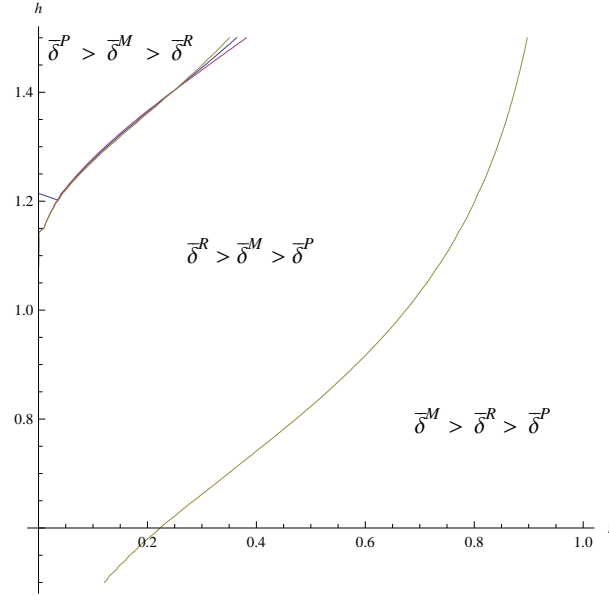


Figure 3.9. Collision stability

Result 10. *Partial collusion is more sustainable than full collusion.*

The threshold of discount factor is smallest for $T = P$ or $T = R$, consequently, partial collusion is more sustainable. Furthermore, R&D cooperation stabilizes the collusion when products are sufficiently differentiated and the technologies are comparatively removed. Otherwise, downstream cooperation sustains the partial collusion.

It is straightforward to show that in $\bar{\delta}^M > \bar{\delta}^R > \bar{\delta}^P$ zone, Full Collusion is the least stable structure. One possible explication refers to the one-shot incentive to deviate:

$$\pi_i^{M,D} - \pi_i^{M,*} > \max\{\pi_i^{R,D} - \pi_i^{R,*}, \pi_i^{P,D} - \pi_i^{P,*}\}$$

therefore, Full Collusion is the least sustainable regime in this zone.

3.5 Concluding remarks

The current chapter studies the significant relevance in the scenarios where firms can either coordinate their decisions or adopt non-cooperative strategy (Full Competition, Full Collusion and Semi-collusion regimes) at each stage. KMZ (1992) claim that the investment by firms engaged in Semi-collusion in R&D regime is unambiguously greater than that in Full Competition regime irrespective of spillovers. We demonstrate in fact which regime generates more R&D effort in equilibrium depends upon both the degree of product differentiation and the sensibility parameter to differentiation. If we restrict our attention to the concave relationship between differentiation and spillover, the ranking of R&D efforts is unalterable and independent of the differentiation degree, competition at the upstream stage depresses R&D investment. Firms colluding in R&D regardless of their production strategy always yield more profit and generate more social welfare than firms colluding in output independently of R&D strategy. When products are close substitutes, full collusion is a welfare-enhancing regime. Within the repeated game, we find that partial collusion is more sustainable than full collusion. Furthermore, R&D cooperation stabilizes the collusion when products are sufficiently differentiated and the technologies are comparatively removed.

In addition, a discussion about antitrust policy is carried out. By focusing upon the distinctness of different antitrust criteria, this framework sheds light on the looseness of total welfare standard and preciseness of consumer welfare standard. And this outcome will be verified, in future work, by considering the interaction between Competition Authorities and firms, in a context of asymmetric information¹⁸. Another possible extension of this framework would be to investigate whether we can get the similar results within a dynamic¹⁹ duopoly game, by supposing the R&D investments for cost-reducing innovation over continuous time.

¹⁸See more in Besanko and Spulber (1989), Pénard and Souam (2002b)

¹⁹See more in Cellini and Lambertini (2004)

Delegation in a spatial game with endogenous spillovers

Abstract: *Several trends of industrial organization are emphasized in this chapter: strategic delegation, R&D with spillovers and product differentiation. We distinguish between two kinds of delegation: Semi-Delegation 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, we show that i). Semi-Delegation encourages one firm to locate farther from the rival, while Full Delegation induces owners to choose the closer location pattern; ii). Semi-Delegation stimulates firms' own spending on R&D, and fosters firms to produce higher quality goods compared to Full Delegation. iii). Semi-Delegation renders managers less aggressive and let managers fix a higher price than Full Delegation. Although there are three Nash equilibrium strategy profiles to this delegation game, the Pareto optimal solution is that both firms choose Semi-Delegation.*

4.1 Introduction

Modern corporations are characterized by a separation of ownership and management, which is considered as the reason for deviation from profit maximization (Skliwas, 1987). There are two main objectives for delegation: the first one is that owners seek to use superior ability, by employing specialized and highly qualified managers to handle sophisticated operations; the second one is that owners can achieve gains from the delegation by means of choosing the strategic commitment. In the current chapter, we study the latter objective by combining elements from the two distinct streams of literature: one based on the analysis of different types of strategic delegation, the other focusing on the modelling of endogenous R&D spillovers in spatial competition framework.

The idea of this chapter is to analyze in this context the impact of delegation (or ownership) structure on firm's location, R&D and price decisions. To that purpose, we contemplate three alternative strategies: No Delegation, Semi-Delegation (delegation of only short-run decisions) and Full Delegation (Delegation of both short-run and long-run decisions).

The delegation introduced by Schelling (1960)¹ 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. Representative papers initiated by Vickers (1985), Fershtman and Judd (1987), Skliwas (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)² are the first

¹Schelling (1960) determines a situation where delegation is being used as a “self commitment device”

²The goal of Zhang and Zhang's analysis was to give a comparison of optimal level of R&D expenditures, production quantities, firm profits and welfare. They demonstrate that managerial delegation will lead to higher R&D investment, higher output, and lower profits in equilibrium

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 the decisions about R&D investment and production quantities to managers. Managerial compensation is based on the performance measures (profits and sales). Bàrcena-Ruiz and Olaizola (2006), Mitrokostas and Petrakis (2005) demonstrate in a similar setup under which circumstances it is optimal to delegate either only the short-run (output) decision or the R&D investment 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. In the above-mentioned papers, and even in the pioneer work of strategic delegation with R&D competition, spillovers are considered as “manna from heaven” (Kamien and 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”. “Impact-spillovers” highlights that spillovers are affected by different kinds of factors, such as absorptive capacity (Cohen and Levinthal, 1990), *ex-ante* adaptability and *ex-post* information sharing (Katsoulacos and Ulph, 1998). “Endogenous spillover” emphasizes that there is a closer relationship between product differentiation and spillovers, particularly in the spatial game. Piga and Poyago-Theotoky (2005)³ (hereafter referred to as PPT), Dey and Fu (2009)⁴ combine the

compared to no delegation case, if spillover effect of R&D is small. We note that Kopel and Riegler (2006) show the results of Zhang and Zhang (1997) may not always hold true and the key results of their work are incorrect due to an improper handling of the first order conditions at the contracting stage. Nonetheless, Zhang and Zhang provide the basic framework to analyze the issue and have opened up an interesting avenue of research.

³Piga and Poyago-Theotoky formulate a three-stage non-cooperative game where two firms choose location, R&D and price, under the assumption that R&D spillovers depend on firms’ location. The closer firms are to each other, the greater the benefit they receive from their rivals’ efforts in quality-enhancing R&D.

⁴Dey and Fu formulate a three-stage model: in the first stage, two *ex-ante* duopolistic firms

conventional spatial competition framework with the competitive process R&D in the presence of endogenous spillovers⁵. The former regards the R&D process as quality-enhancing activity, and the latter considers it as cost-saving activity. They both relate the extent of spillovers to firms' product configuration. Our framework adopts the PPT (Piga and Poyago-Theotoky, 2005) model, and combines the strategic delegation with endogenous spillovers, in order to gain some insights into the interdependence of ownership structure, firm's location pattern, product variety, product quality and market competition.

The contribution of this chapter is three-fold. First, we extend the strategic delegation game by introducing the endogenous spillovers. This allows us to study how the delegation structure affects firms' location⁶, 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: Semi-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.

Markets are characterized by both horizontal and vertical differentiation⁷. Vertical differentiation reflects that the competing firms produce distinct quality levels. And horizontal differentiation is characterized by different locations of the firms

simultaneously choose the locations, and then they engage in competitive cost-reducing R&D in the seconde stage, finally they compete in price.

⁵The papers embracing the notion of endogenous spillovers, claim that firms would be more likely to conduct research in common areas when they manufacture homogenous goods, because producing similar goods usually demands parallel technical solutions or common inputs. The common research enables competing firms to realize more technological opportunities. In addition, similar production processes allow firms to adapt the technological know-how they learn from one another to their own needs.

⁶As the literature on spatial competition points out, the location of the firm can also be interpreted as product variety. This literature (see, for example, d'Aspremont et al., 1979) usually considers that firms ought to be located within the city limits.

⁷For instance, apparel, garments and shoes have an amazingly rich combination of shapes, colours, materials, complementarities, seasonal and territorial specificities, appropriateness to social events, relative distance to ideals promoted by media, stylists and the showbusiness. The quality of the materials can often be seen as a vertical differentiation but some other elements are clearly horizontal, like shapes.

in a Hotelling linear city; alternatively, it reflects consumers' preferences for different brands in the product space. Within this framework, the location space is considered as the range of product variants; the firms' locations not only indicate the product variety but also reflect the extent of R&D spillovers.

Our analysis is conducted in a four-stage game. In the first stage, owners⁸ choose their locations simultaneously. In the second stage, owners either decide on R&D effort or delegate this decision to managers, in which case, the owners choose an incentive contract to maximize the profit. Notice that the delegation at this stage also implies delegation of the price decision in the next stage. In the third stage, owners can decide to delegate the price decision or retain it for themselves, if there is no delegation in the previous stage. Finally, the decision-makers (either owners or managers) simultaneously decide the price. Overall, there are three alternative strategies: No Delegation, Semi-Delegation and Full Delegation. Obviously, the incentive schemes are simultaneously decided in symmetric cases, while they are sequentially chosen in the asymmetric cases where Semi-Delegation and Full Delegation co-exist.

Both empirical evidence and various examples can be used to illustrate Semi- and Full Delegations. It is shown that owners tend to delegate only short-run decisions to their managers, while they prefer to preserve control on the long-run decisions, in some companies. For instance, the owners of BMW⁹ are very much involved in the management of the firm (in their long-run decisions), at the same time, they delegate short-run decisions such as marketing plans to the managers of subsidiaries. The owners of Benneton are very involved in the long-run decisions.

⁸In practice, owners make the most important location decision. One theoretical paper pays attention to this phenomenon: Bárcena-Ruiz and Casado-Izaga (2005) show that owners have incentives to keep the decisions of firm location for themselves.

⁹The case of the BMW (Bavarian Motor Works) company illustrates the Semi-Delegation situation. In this company, in 1984, between 50 and 75% of the property of the firm was in the hands of the Quandt family who also held a very active position in the supervisory board of BMW; the remainder of the firm was owned by a group of European banks and employees of the firm. The owners of BMW were very much involved in the management of the firm (in their long-run decisions) but, at the same time, they delegate short run decisions such as marketing plans to the subsidiaries. As Jenster et al. (1990, p. 142) point out: Although the parent company, BMW in Munich, established broad guidelines, the subsidiary managers are responsible for developing their own strategic objectives and marketing plans within their regions.

As Jarillo and Martnez (1990, p. 72) explain: Benneton approved location of the shops and Luciano (the owner) personally oversaw the more strategic sites. Additional evidence is given by Microsoft¹⁰, where Bill Gates plays a dominant role in the 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).

Concerning managerial contracts, we adopt the incentive contracts consist of a combination of profits and market share. Much anecdotal evidence about the importance of market share motives emerged in the business press and management literature. A classic example is Jack Welch's General Electric, which publicly announced that its key objective is to be number one in 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 empirical¹¹ viewpoint, Peck (1988) mentions that the market share is highly ranked in managers' objectives. In the survey for corporate objectives among 1000 American and 1031 Japanese top managers, Peck (1988) documents that increasing market share is ranked third in the American and second in the Japanese sample. All these arguments induce us to explore the delegation game with market share contracts¹².

This chapter not only explores the issue of whether owners choose the strategic commitment to achieve gains from the delegation, but also answers to question what type of delegation they prefer to adopt. We analyze the incentive contracts that the owners choose for their managers focusing on how owners may strategically

¹⁰Bill Gates, the main owner, plays a dominant role in the strategic decisions of the firm. As *The Economist* (July 10th 1999, p. 88) read: Could any manager be more firmly entrenched at the head of his company than Bill Gates?

¹¹Borkowski (1999) analyzes managerial performance evaluation on the basis of questionnaire data from 261 firms in servery countries (Canada, Germany, Japan, United Kingdom and the United States) and finds that market share often emerged as important.

¹²There are some theoretical papers focussing on the market share contracts. Jansen et al.(2007) and Ritz (2008) formalize the case of Market Share contracts. Their main result is that for the case of Cournot (Bertrand) competition, quantities (prices) set from managers compensated with Market Share contracts are higher than those set by strict profit-maximizing owners.

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 the delegation policies benefit consumers and give rise to a higher level of social welfare. In a more general analysis, we demonstrate although there are three Nash equilibrium strategy profiles to this delegation game, the *Pareto* optimal solution is that both firms choose Semi-Delegation.

It is found that Semi-Delegation increases the product variety, fosters firms to spend more on R&D, encourages firms to produce high-quality goods and renders managers less aggressive, hence increases prices and profits, however, it decreases consumer surplus and social welfare. By contraries, under Full Delegation, owners choose the closer location pattern, managers decide to invest less on R&D and produce low-quality goods, firms achieve less profit compared to Semi-Delegation case. The findings are in contrast with the main result of Mitrokostas and Petrakis (2005) which highlights the more investment in R&D under Full Delegation. The introduction of spillover effect induces firms under Semi-Delegation to plough a large sum into R&D.

The remainder of the chapter is organized as follows. Section 4.2 describes the model and section 4.3 explores the equilibrium in three alternative (symmetric) scenarios. In section 4.4, we derive our main results about location, R&D, price and profit. Then, section 4.5 relates to the analysis in terms of consumer surplus and social welfare. We proceed the more general study in section 4.6, where the asymmetric cases are taken into account. Some brief concluding remarks are offered in section 4.7.

4.2 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 $y_i \in [0, 1]$ 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 $\lambda \in [0, 1]$ 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 the distance between two firms, the more differentiated the firms' products, the less the R&D spillovers¹³. Define $\lambda = 1 - y_j + y_i$ which is at a maximum when firms share the same location ($y_i = y_j$) and will be the minimum value when firms located at the 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 $\frac{\gamma x_i^2}{2}$, where γ is a measure of effectiveness¹⁴ of R&D.

Assume each firm has a principal (*i.e.* owner, board of directors, shareholder) and an agent (*i.e.* manager, CEO), the 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 the firm's profit $\pi_i = p_i D_i - \frac{\gamma}{2} x_i^2$ and has the option to hire a manager to make the short-run price and/or the long-run R&D investment decisions.

A manager's objective function¹⁵ in the product market places weight on both profits and market share

$$U_i = \pi_i + \theta_i \frac{D_i}{D_i + D_j}$$

where the weight θ_i is a number chosen by owner i in order to maximize his profit.

¹³The product characteristic choices of the firms define the areas in which they undertake R&D. When firms produce more similar products, their R&D areas are more likely to overlap. Therefore, this enables each firm to harness the knowledge leaked from the other's R&D. See detail in Dey and Fu (2009)

¹⁴As γ increases, the expenditure required for a firm to obtain a given quality increases.

¹⁵The results presented are unchanged if the objective function is instead written as $U_i = \theta_i \pi_i + (1 - \theta_i) \frac{D_i}{D_i + D_j}$, since what matters is only the relative weight on the performance measures. The formulation in the main text simplifies the notation.

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:

1. Owners choose the location simultaneously.
2. Owners either decide on R&D effort or delegate this decision to managers, in which case, the owners choose a contractual parameter θ_i ; Delegation at this stage also implies delegation of the price decision in the next stage.
3. Owners can decide to delegate the price decision or retain it for themselves.
4. Decision-makers (either owners or managers) simultaneously decide the price.

Notice that the contracts (incentive schemes) can not be renegotiated and they become common knowledge¹⁶ once they are signed. Overall, owners have three alternative strategies: No Delegation, Semi-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.

There are three symmetric cases: (No Delegation, No Delegation), (Semi-Delegation, Semi-Delegation), (Full Delegation, Full Delegation); and six asymmetric cases¹⁷: (No Delegation, Semi-Delegation), (No Delegation, Full Delegation), (Semi-Delegation, No Delegation), (Semi-Delegation, Full Delegation), (Full Delegation, No Delegation), (Full Delegation, Semi-Delegation).

¹⁶The assumption that incentive contracts become common knowledge when the contract is signed is necessary. If this assumption is not considered, the contracts cannot act as commitment devices (see Katz, 1991). Fershtman and Judd (1987) argue that incentive contracts are costlier variables to change than price, and therefore remain unaltered for a substantial amount of time (while price decisions are being changed), and they are likely to be observed by rivals.

¹⁷See analysis of asymmetric cases in section 6.

tion), (Semi-Delegation, Full Delegation)...

As shown in PPT (2005), suppose a consumer located at $s \in [0, 1]$, 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 $t > 0$ refers to an index of the transportation cost¹⁸ per unit, it indicates the degree of consumer heterogeneity. The basic reservation utility $v > 0$ is sufficiently large so that the market¹⁹ 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 (in case of No Delegation, Semi-Delegation) or managers (in case of Full Delegation). Furthermore, the firm's locations also represent the characteristics of products (horizontal differentiation). 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.

4.3 Equilibrium and Analysis

In this section, we focus on symmetric cases and solve for the equilibrium of this multi-stage game by backward induction. Before the resolution of the model, we first of all 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

¹⁸The quadratic cost assumption is invoked in order to guarantee existence of equilibrium. This assumption is also used in other papers that study spatial competition between firms, for example, Neven (1985), Tabuchi and Thisse (1995), Brekke and Straume (2004) and Liang and Mai (2006). It is well known that linear transport costs lead to severe problems of existence of equilibrium in the price sub-game. See d'Aspremont et al.,(1979).

¹⁹To avoid any arbitrage between consumers, assume that the transaction costs for the resale of goods are prohibitively high.

demands addressed to firm i and firm j .

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

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

No Delegation (Benchmark case)

In this scenario, none of owners delegate the decisions to managers, thus, owners sequentially choose firm's locations, R&D efforts and prices. This benchmark case coincides with the work realized by PPT (2005)²⁰ which do not focus on the issue of managerial delegation. The solution concept is the sub-game perfect equilibrium by backward induction.

Price stage

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

$$\pi_i = p_i D_i - \frac{\gamma x_i^2}{2}$$

$$\pi_j = p_j D_j - \frac{\gamma x_j^2}{2} \quad (4.1)$$

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

$$p_i = \frac{1}{3} [X_i - X_j + t(y_j - y_i)(2 + y_i + y_j)]$$

$$p_j = \frac{1}{3} [X_j - X_i + t(y_j - y_i)(4 - y_i - y_j)] \quad (4.2)$$

Substituting the equilibrium prices *Eqs.* (4.2), into the expressions for profits

²⁰The results presented by Piga and Poyago-Theotoky (2005) are relevant only for a very small range of the transportation cost parameter, namely $t \in (\frac{2}{9}, \frac{5+\sqrt{13}}{9})$. In order to avoid this restriction problem on the value of transportation cost, we introduce the parameter γ which refers to the index of effectiveness of R&D.

Eqs. (4.1), we obtain:

$$\begin{aligned}\pi_i &= \frac{[X_i - X_j + t(y_j - y_i)(2 + y_j + y_i)]^2}{18t(y_j - y_i)} - \frac{\gamma x_i^2}{2} \\ \pi_j &= \frac{[X_j - X_i + t(y_j - y_i)(4 - y_j - y_i)]^2}{18t(y_j - y_i)} - \frac{\gamma x_j^2}{2}\end{aligned}\quad (4.3)$$

R&D (quality) stage

We now explore firms' equilibrium R&D decisions in this stage, with a given location profile (y_i, y_j) . Using the expressions for profits derived *Eqs. (4.3)*, in addition, the expressions for effective R&D $(X_i = x_i + (1 - y_j + y_i)x_j$ and $X_j = x_j + (1 - y_j + y_i)x_i)$, after taking *FOCs*²¹ we obtain the equilibrium R&D efforts.

$$\begin{aligned}x_i &= \frac{(y_j - y_i)[3t\gamma(2 + y_i + y_j) - 2(y_j - y_i)]}{3\gamma[9t\gamma - 2(y_j - y_i)]} \\ x_j &= \frac{(y_j - y_i)[3t\gamma(4 - y_i - y_j) - 2(y_j - y_i)]}{3\gamma[9t\gamma - 2(y_j - y_i)]}\end{aligned}\quad (4.4)$$

Based on the expressions of R&D efforts established (*Eqs. (4.4)*), firms' profits can be written as the following function of their locations:

$$\begin{aligned}\pi_i &= \frac{(y_j - y_i)[9t\gamma - (y_j - y_i)][3t\gamma(2 + y_i + y_j) - 2(y_j - y_i)]^2}{18\gamma[9t\gamma - 2(y_j - y_i)]^2} \\ \pi_j &= \frac{(y_j - y_i)[9t\gamma - (y_j - y_i)][3t\gamma(4 - y_i - y_j) - 2(y_j - y_i)]^2}{18\gamma[9t\gamma - 2(y_j - y_i)]^2}\end{aligned}\quad (4.5)$$

Location stage

In the absence of managerial delegation, firms' location patterns affect their payoffs through two avenues: A firm's location pattern alters its incentive to conduct R&D as well as the resultant product quality, while it further affects the firm's pricing strategy in the product market. In this stage, owners simultaneously choose their locations $(y_i$ and $y_j)$ to maximize their profits. The expressions *Eqs. (4.5)*

²¹Note that the condition $t > \frac{2}{9\gamma}$ is necessary to guarantee the equilibrium existence under No Delegation scenario.

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	$\pi_i^N = \pi_j^N = \frac{9t^2\gamma}{4(2+3t\gamma)}$

Table 4.1. Equilibrium values under No Delegation

allow us to investigate the equilibrium of the location game. Taking *FOCs* and then restricting the resulting solution to a symmetric one, we obtain the following equilibrium²²:

$$\begin{aligned}
 y_i &= \frac{4 - 12t\gamma - 27t^2\gamma^2 + 9t\gamma\sqrt{3t\gamma(2+3t\gamma)}}{4(2+3t\gamma)} \\
 y_j &= \frac{4 + 24t\gamma + 27t^2\gamma^2 - 9t\gamma\sqrt{3t\gamma(2+3t\gamma)}}{4(2+3t\gamma)}
 \end{aligned} \tag{4.6}$$

By making use of *Eqs.* (4.6), we can compute the equilibrium levels for all other relevant variables. These values are shown in Table 4.1.

Semi-Delegation

According to Semi-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 about their R&D efforts, and then set the incentive schemes for their managers. Finally, managers compete by setting the prices.

Price stage

We begin with the price chosen by managers who seek for the maximization of

²²In general, we obtain two sets of candidate equilibrium locations. The one displayed in main text satisfies the stability condition, the other one dissatisfies the stability condition, thus, it is eliminated.

their utilities:

$$\begin{aligned} U_i &= p_i D_i - \frac{\gamma x_i^2}{2} + \theta_i D_i \\ U_j &= p_j D_j - \frac{\gamma x_j^2}{2} + \theta_j D_j \end{aligned} \quad (4.7)$$

It is straightforward to show that the product prices chosen by managers are given by:

$$\begin{aligned} p_i &= \frac{1}{3} [X_i - X_j + t(y_j - y_i)(2 + y_i + y_j) - (2\theta_i + \theta_j)] \\ p_j &= \frac{1}{3} [X_j - X_i + t(y_j - y_i)(4 - y_i - y_j) - (\theta_i + 2\theta_j)] \end{aligned} \quad (4.8)$$

We emphasize that the difference between these expressions of price (*Eqs.* (4.8)) and the price expressions in Benchmark case (*Eqs.* (4.2)) is the term $-(2\theta_i + \theta_j)$ for firm i and $-(\theta_i + 2\theta_j)$ for firm j . Evidently, owners are able to manipulate the managers' behaviors by the incentive scheme: the positive value of incentive parameters reduce the prices chosen by managers, on the contrary, the negative value of contract can increase the price. We will make the in-depth analysis of incentive scheme in the following section.

Contracting stage

At the contract stage, owner establishes his manager's incentive contract, which consists of a linear combination of profit and market share. The owner's objective here is to manipulate his manager's contract such that, given the rival's contract, his profit is maximized. Substituting the *Eqs.* (4.8) into the profit functions *Eqs.* (4.1), we can derive the expressions of firms' profits with regard to the contracts, R&D efforts and product locations *i.e.* $\pi_i(y_i, y_j, x_i, x_j, \theta_i, \theta_j)$. The owners choose the incentive schemes in order to maximize the firms' profits:

$$\begin{aligned} &\max_{\theta_i} \pi_i(y_i, y_j, \theta_i, \theta_j, x_i, x_j) \\ &\max_{\theta_j} \pi_j(y_i, y_j, \theta_i, \theta_j, x_i, x_j) \end{aligned}$$

We obtain:

$$\begin{aligned}\theta_i &= \frac{1}{5} [X_j - X_i - t(y_j - y_i)(4 + y_i + y_j)] \\ \theta_j &= \frac{1}{5} [X_i - X_j - t(y_j - y_i)(6 - y_i - y_j)]\end{aligned}\quad (4.9)$$

R&D (quality) stage

In this stage, owners choose their R&D efforts non-cooperatively, taking locations (y_i, y_j) as given. Using the expressions of incentive schemes derived in the previous stage (Eqs. (4.9)) and expressions for effective R&D ($X_i = x_i + (1 - y_j + y_i)x_j$), after taking *FOCs*, we hence obtain the equilibrium R&D efforts:

$$\begin{aligned}x_i &= \frac{2(y_j - y_i) [5t\gamma(4 + y_i + y_j) - 4(y_j - y_i)]}{5\gamma [25t\gamma - 4(y_j - y_i)]} \\ x_j &= \frac{2(y_j - y_i) [5t\gamma(6 - y_i - y_j) - 4(y_j - y_i)]}{5\gamma [25t\gamma - 4(y_j - y_i)]}\end{aligned}\quad (4.10)$$

Location stage

Return to the first stage, the owners decide the firms' locations to maximize their profits, anticipating how this choice will affect their subsequent choices of R&D and price. We concentrate on symmetric equilibria outcomes to obtain analytical solutions. Making use of the expressions for R&D effort (Eqs. (4.10)) and putting them into owners' objective functions and then taking *FOCs*, we obtain the equilibrium locations:

$$\begin{aligned}y_i &= \frac{16 - 5t\gamma [16 + 25t\gamma - 5\sqrt{5t\gamma(4 + 5t\gamma)}]}{8(4 + 5t\gamma)} \\ y_j &= \frac{16 + 5t\gamma [24 + 25t\gamma - 5\sqrt{5t\gamma(4 + 5t\gamma)}]}{8(4 + 5t\gamma)}\end{aligned}\quad (4.11)$$

To ensure that the firms' locations chosen by owners lie in the interior market and satisfy the condition $0 \leq y_i \leq y_j \leq 1$, we restrict the value of transportation cost t to $\underline{t} < t \leq \bar{t}$ with $\underline{t} = \frac{5}{18\gamma}$ and $\bar{t} = \frac{2(9+\gamma\sqrt{21})}{75\gamma}$. This assumption guarantees the overall game (three alternative scenarios).

The equilibrium R&D efforts, managerial contracts, prices, qualities and profits

Equilibrium Values	Semi-Delegation (superscript “S”)
R&D investment	$x_i^S = x_j^S = \frac{5t\gamma [4+5t\gamma - \sqrt{5t\gamma(4+5t\gamma)}]}{2\gamma(4+5t\gamma)}$
Quality	$X_i^S = X_j^S = \frac{5 [t\gamma(25t\gamma-4)\sqrt{5t\gamma(4+5t\gamma)} + 16t\gamma - 5t^2\gamma^2(6+25t\gamma)]}{4\gamma(4+5t\gamma)}$
Contract	$\theta_i^S = \theta_j^S = \frac{25t^2\gamma [\sqrt{5t\gamma(4+5t\gamma)} - (4+5t\gamma)]}{4(4+5t\gamma)}$
Price	$p_i^S = p_j^S = \frac{25t^2\gamma [(4+5t\gamma) - \sqrt{5t\gamma(4+5t\gamma)}]}{2(4+5t\gamma)}$
Profit	$\pi_i^S = \pi_j^S = \frac{25t^2\gamma}{2(4+5t\gamma)}$

Table 4.2. Equilibrium values under Semi-Delegation

are shown in Table 4.2.

Full Delegation

In this scenario, owners delegate both the long-run R&D decisions and the short-run price decisions to managers. Accordingly, owners first of all choose the firms' positions, and then decide the incentive schemes to maximize the firms' profits. The managers take charge of R&D and price decisions on owner's behalf.

Price stage

The managers will choose prices so as to maximize their objective functions which depend upon the linear combination of profit and market share. It is straightforward to derive the same expressions of price as the previous Semi-Delegation scenario.

R&D (quality) stage

The managers choose R&D efforts in this stage. Using *Eqs.* (4.8), we rewrite the managers' rewards as function of R&D efforts, contracts and firms' locations.

$$U_i = \frac{A^2 - 2x_i(y_j - y_i)A + x_i^2(y_j - y_i)(y_j - y_i - 9t\gamma)}{18t(y_j - y_i)} \quad (4.12)$$

$$\text{with } A = (y_j - y_i)[x_j - t(2 + y_i + y_j)] - \theta_i + \theta_j$$

$$U_j = \frac{B^2 - 2x_j(y_j - y_i)B + x_j^2(y_j - y_i)(y_j - y_i - 9t\gamma)}{18t(y_j - y_i)} \quad (4.13)$$

$$\text{with } B = (y_j - y_i)[x_i - t(4 - y_i - y_j)] - \theta_i + \theta_j$$

From the *FOCs* of the managers' rewards, we derive

$$\begin{aligned} x_i &= \frac{3t\gamma(y_j - y_i)(2 + y_i + y_j) - 2(y_j - y_i)^2 + 3\gamma(\theta_i - \theta_j)}{3\gamma[9t\gamma - 2(y_j - y_i)]} \\ x_j &= \frac{3t\gamma(y_j - y_i)(4 - y_i - y_j) - 2(y_j - y_i)^2 + 3\gamma(\theta_j - \theta_i)}{3\gamma[9t\gamma - 2(y_j - y_i)]} \end{aligned} \quad (4.14)$$

Contracting stage

Each owner seeks to maximize his profit by properly choosing the weight in the manager's contract. The contracts are given by:

$$\begin{aligned} \theta_i &= - \frac{(y_j - y_i)[9t\gamma - 4(y_j - y_i)][9t\gamma(4 + y_i + y_j) - 14(y_j - y_i)]}{9\gamma[45t\gamma - 14(y_j - y_i)]} \\ \theta_j &= - \frac{(y_j - y_i)[9t\gamma - 4(y_j - y_i)][9t\gamma(6 - y_i - y_j) - 14(y_j - y_i)]}{9\gamma[45t\gamma - 14(y_j - y_i)]} \end{aligned} \quad (4.15)$$

Location stage

Owners decide on the locations of firms in order to maximize their profits. By solving this problem, we get

$$\begin{aligned} y_i &= \frac{140 - 9t\gamma[29 + 18t\gamma - \sqrt{121 + 36t\gamma(14 + 9t\gamma)}]}{20(14 + 9t\gamma)} \\ y_j &= \frac{140 + 9t\gamma[49 + 18t\gamma - \sqrt{121 + 36t\gamma(14 + 9t\gamma)}]}{20(14 + 9t\gamma)} \end{aligned} \quad (4.16)$$

Then the equilibrium levels for all other relevant variables are shown in Table 4.3.

Equilibrium Values	Full Delegation (superscript “F”)
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	$X_i^F = X_j^F = \frac{3t\gamma \left[\sqrt{121+36t\gamma(14+9t\gamma)}(162t^2\gamma^2+261t\gamma-140) - 2916t^3\gamma^3 - 6966t^2\gamma^2 - 1359t\gamma + 5460 \right]}{50\gamma(9t\gamma+14)^2}$
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	$\pi_i^F = \pi_j^F = \frac{9t^2\gamma \left[11\sqrt{121+36t\gamma(14+9t\gamma)} + 271 + 252t\gamma \right]}{20(14+9t\gamma)^2}$

Table 4.3. Equilibrium values under Full Delegation

4.4 Results

By using the outcomes established in the previous section, we compare²³ the three alternative delegation strategies in terms of firm’s location, R&D spillovers, product quality, market price and profit.

Firm’s location

Each owner chooses his firm’s location before subsequently conducting R&D activity and marketing the product decided by either himself or his manager. The impact of location configuration decision is two-fold: on the one hand, it determines the extent of product (horizontal) differentiation; on the other hand, the 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 to take advantage of more information flow.

Through the comparison of optimal locations in different symmetric scenarios²⁴, we find the following result:

²³The comparison of all relevant equilibrium values is based on the assumptions: the R&D effectiveness measure positive ($\gamma > 0$) and the transportation cost in the interval (\underline{t}, \bar{t}) , with $\underline{t} = \frac{5}{18\gamma}$ and $\bar{t} = \frac{2(9+\gamma\sqrt{21})}{75\gamma}$.

²⁴i.e. *Eqs.* (4.6) for No Delegation and *Eqs.* (4.11) for Semi-Delegation and *Eqs.* (4.16) for Full Delegation.

Result 11. $0 \leq y_i^S < y_i^N < y_i^F < \frac{1}{2} < y_j^F < y_j^N < y_j^S \leq 1$

The firms' equilibrium location pattern balances the tradeoff 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 firm i and firm j 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 the price competition, within Full Delegation, therefore, owners always have more incentive to position their products closer to each other.

We also find the Semi-Delegation strategy encourages one firm to locate farther from the rival. In particular, the firms could locate at the two respective extremities of market that generates the minimal spillover effect when the transportation rate is equal to the upper bound²⁵ \bar{t} . In addition, it is clear that firms never share the same place which gives rise to the maximal spillovers.

As the extent of spillovers $\lambda = 1 - y_j + y_i$ depends upon the firms' locations, more precisely, the distance between competing firms, it is straightforward to derive the following result:

Result 12. $1 > \lambda^F > \lambda^N > \lambda^S \geq 0$ and $0 > \frac{\partial \lambda^N}{\partial t} > \frac{\partial \lambda^F}{\partial t} > \frac{\partial \lambda^S}{\partial t}$

The extent of spillover (or the distance between competing firms) is a decreasing (or an increasing) function of transportation cost. Therefore, the geographical and researchful isolation is preferred when firms are protected by higher transport cost. There are two factors influencing this result. On the one hand, 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

²⁵As shown in previous Analysis section, the lower and upper bounds of transportation cost are respectively $\frac{5}{18\gamma}$ and $\frac{2(9+\gamma\sqrt{21})}{75\gamma}$.

spillovers. The lower 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 the 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 benchmark case, Full Delegation strategy gives rise to higher R&D spillovers, whereas, Semi-Delegation strategy leads to lower spillovers. When owners delegate the 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 case of Full Delegation, owners have less incentives to position firms far away compared to Semi-Delegation, because the gains from a closer location pattern within Full Delegation are greater than that within Semi-Delegation, this effect reduces the tendency to separate.

Research and Development effort

By comparing the equilibrium levels of R&D effort in different scenarios²⁶, we obtain:

Result 13. $x^S > x^N > x^F > 0$

As demonstrated in the previous subsection, Semi-Delegation strengthens firms' incentives for product differentiation and propels firms to further segregate the market; by contraries, Full Delegation encourages firms to position closely in order to reduce the product heterogeneity and to reinforce the R&D sharing. Thus, the delegation influences the choice of firm's location, in turn, affects the R&D spillovers, and will indirectly (No and Semi-Delegation) or directly (Full Delegation) have an effect on R&D investment. For instance, Semi-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 case of Full Delegation, firms are

²⁶See Tables 4.1, 4.2 and 4.3

located closer, two opposite effects come into play sharply. A lower level of differentiation forces the firms to charge a lower price, while diluted R&D competition leads to less R&D investment. Evidently, the firms within Full Delegation spend less on R&D due to the sufficiently “large” spillover effect, while firms within Semi-Delegation have to spend more on R&D because of the “small” spillover effect.

It is worth noting that in Semi-Delegation case, firms possibly locate at the endpoints ($y_i = 0; y_j = 1$). 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.

Quality

Horizontal differentiation is determined by the different locations of the firms, while vertical differentiation is captured by the consideration that the firms produce distinct product qualities, endogenously specified and denoted by X_i and X_j . Let us now compare the equilibrium values of effective R&D efforts, *viz* product quality. The expressions of X^N , X^S and X^F are respectively shown in Table 4.1, 4.2 and 4.3.

Result 14. $X^S > X^N > X^F > 0$

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, which are chosen by owners under No and Semi-Delegation, particularly chosen by managers under Full Delegation. Obviously, the former factor is completely controlled by owners, however, the latter one could be determined by managers. According to Result 14, the product quality is higher if the owners control both factors, while the quality is lower if the managers decide the R&D factor. Furthermore, combined with the Result 11, we deduce that from the perspective of product differentiation²⁷, Semi-Delegation generates

²⁷In contrast with the horizontal differentiation chosen by owners, the vertical differentiation is determined by owners’ locational decisions and managers’ R&D decisions under Full Delegation scenario.

higher product variety and higher product quality, by contrast, Full Delegation leads to lower variety and lower quality.

Incentive scheme

Without taking into account asymmetric cases, the incentive schemes are always simultaneously decided. The owners make the incentive schemes and announce the managers' contracts publicly, and after observing the contracts, the managers maximize the payoff given the reward contracts. By comparing the equilibrium incentive parameters, we obtain the following result:

Result 15. $\theta^S < \theta^F < 0$

Firstly, we find that in equilibrium the incentive contracts parameters are negative. This result corresponds to some cases where it may be advantageous to ask manager to decrease market share. For example, if a firm is able to identify certain customers (or market segments) that are unprofitable, it may drop those customers and lose market share²⁸ while improving profitability.

We firstly focus upon the intuition behind the result under Semi-Delegation. The incentive contract θ_i just affects the subsequent price decision, a higher value of θ_i gives rise to a lower price p_i , because the manager tends to put more stress on the market share. The rival firm j moves far away from the market center to escape the tougher competition resulting from the higher value of θ_i . Since the strategic is complementarity, on anticipating this fact, each owner will set a lower incentive scheme parameter in order to mitigate the subsequent price competition.

When the owners delegate both short-run price and long-run R&D decisions, the incentive contract θ_i plays an important role not only in the price stage but

²⁸There are some other examples which illustrate the reasons not to increase market share: 1. Overall profits may decline if market share is gained by increasing promotional expenditures or by decreasing prices; 2. A small niche player may be tolerated if it captures only a small share of the market. If that share increases, a larger, more capable competitor may decide to enter the niche; 3. Antitrust issues may arise if a firm dominates its market.

also in the R&D stage. A higher value of incentive parameter leads to a lower price p_i and a stronger effective R&D effort X_i , because the manager tends to attach more importance to market share. This lower price p_i and the stronger effective R&D effort X_i will influence the owners' location choices. Two firms tend to move far away towards the endpoint of market so as to soften price competition, but they expect that 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^S) by anticipating the aforementioned fact.

By comparing the expressions at price stage under No Delegation *Eqs.* (4.2) to that under Delegation (Semi- and Full Delegation) *Eqs.* (4.8), the differences are the term $-(2\theta_i + \theta_j)$ for firm i and $-(2\theta_j + \theta_i)$ for firm j . Since owners set the negative weight on market share in equilibrium, it discloses that the managerial contracts make the managers less aggressive.

Price

By comparing the equilibrium prices under three different scenarios, we have the following result.

Result 16.

$$\begin{cases} p^S > p^N \geq p^F > 0 & t \in (\underline{t}, \tilde{t}] \\ p^S > p^F > p^N > 0 & t \in (\tilde{t}, \bar{t}] \end{cases}$$

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

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

Semi-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, the competition in price becomes soft, the decreasing spillover weakens the R&D free-ride and forces firms to carry on more individual R&D efforts. The softened price competition and the 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 the 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 the transportation cost is sufficiently large ($t > \tilde{t}$), 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.

Profit

The comparison in terms of profits, allows us to analyze whether it is in the interest of owners to delegate the short-run decision or both short- and long-run decisions to managers. Three scenarios have already been looked into and the firms' profits are shown in Tables 4.1, 4.2 and 4.3 respectively.

Result 17. $\pi^S > \pi^F > \pi^N > 0$

It is straightforward to show that the profit of managerial firms is always higher than the profit of owner-managed (or entrepreneurial) firms. In particular, the Semi-Delegation strategy results in higher level of profit without ambiguity than Full Delegation.

First, we focus on the inequality $\pi^S > \pi^F$. The intuition underlying this finding is largely based on the aforementioned results we have detailed. Owners, by using an incentive contract strategically, direct their managers to a less aggressive behavior in order to soften the price competition and to increase the price of product. Since the value of incentive scheme under Semi-Delegation is lower than that under Full Delegation (Result 16), the equilibrium price in Semi-Delegation case will be higher (Result 17). When owners delegate the long-run R&D decisions to their managers, they spur the managers to enhance the product quality, in other words, to conduct more effective R&D efforts which are realized by two channels: more investment and closer location. The firm decides to draw the rival closer in order to benefit more *via* spillovers at no cost (Result 12) instead of investing more on his own R&D (Result 14), thus firms economize the cost on R&D. Nevertheless, the gains from the rise of price caused by Semi-Delegation are much higher than the gains from economizing the cost of R&D under Full Delegation. Consequently, the Semi-Delegation strategy is always more profitable compared to the Full Delegation.

Although the equilibrium price under Full Delegation is not always higher than the price in benchmark case (Result 16), the managerial firms within 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 the 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.

To sum up, Full Delegation lets the firms adopt a closer location pattern, invest less on R&D and produce the low-quality goods. By contraries, Semi-Delegation encourages the firm to locate farther from the rival and to spend more on R&D, thereupon, firms produce the high-quality goods and generate the highest level of profit amongst three possible delegation scenarios. In the following section, we will investigate how Semi- and Full Delegation strategies influence the consumer surplus and social welfare.

4.5 Consumer surplus and Social Welfare

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

Let “CS” denote consumer surplus²⁹ and “W” represent social welfare. Consumer surplus and social welfare are given by

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

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

Since No Delegation is considered as a benchmark, the CS and W in benchmark case will be the standard level. If the strategic delegation generates a higher level than standard level, this delegation refers to the strategy which reinforces the social incentive; otherwise, it refers to the strategy that harms collective gains. We highlight the composition of CS and W for the different scenarios in **Appendix D.1**.

By comparing the consumer surplus and the social welfare under different scenarios, we derive:

Result 18. $CS^N > CS^F > CS^S$ and $W^F > W^N > W^S$

²⁹The effective R&D “ X_i ” is transformed into consumer’s value, that is interpreted as quality (enhancement).

Combined with the analysis in terms of profits (see Result 17), we demonstrate that the delegation schemes are profitable for firms, however they are never beneficial to consumers. Full Delegation is the efficient strategy which generates the highest level of social welfare. In Semi-Delegation case, the high price certainly leads to the decrease of consumer surplus and aggregate surplus, in spite of high product quality.

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

By contraries, under Full Delegation, owners choose the closer location pattern. The impact of owners' locational decisions is two-fold: first, it determines the lower extent of 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 the product quality. It is detrimental to consumer surplus on the one hand, while being propitious to firms on the other hand. A lower level of horizontal differentiation forces firms to face intensified price competition so that firms cut down the price. This benefits consumers on a large scale, and then enhance the social welfare. We highlight that Full Delegation is a more efficient strategy, which not only brings on the profits but improves the social welfare as well.

4.6 More general analysis: asymmetric games

So far, we have analyzed the delegation effect in location-R&D-price framework by following the simple and symmetric way. In this section, we allow the possibility of asymmetry, *i.e.*, the delegation strategy of firm i can be different from the one of firm j . There are several possible combinations: 1). the one chooses No Delegation, while the other one chooses Semi-Delegation, “ (N, S) or (S, N) ”; 2). No Delegation within the one and Full Delegation within the other, “ (N, F) or (F, N) ”; 3). Semi-Delegation in one and Full Delegation in other one “ (S, F) or (F, S) ”. Under the latter one, the incentive schemes (or contracts) are chosen sequentially³⁰ by owners.

The calculation and the expression of firm’s payoff in the above-mentioned possibilities are demonstrated in **Appendix D.2**. Within two-player games, the normal form can be represented by using the payoff matrix (Figure 4.1). The strategies available for firm i (interchangeably the *row* player) are the rows and the strategies available for firm j (interchangeably the *column* player) are the columns. The payoffs associated with any pair of strategies are given by the appropriate cell. The first expression is the payoff to firm i (the *row* player) while the second one is the payoff from that strategy profile for firm j (the *column* player). Both firms have the strategy set $\{N, S, F\}$, and any combination can be played.

³⁰Bárcena-Ruiz and Espinosa (1996) and Bárcena-Ruiz and Casado-Izaga (2005) consider also the game in which incentive parameters can be chosen sequentially.

		Firm j		
		No Delegation	Semi-delegation	Full Delegation
Firm i	No Delegation	$\Pi_i^{(N,N)}, \Pi_j^{(N,N)}$	$\Pi_i^{(N,S)}, \Pi_j^{(N,S)}$	$\Pi_i^{(N,F)}, \Pi_j^{(N,F)}$
	Semi-delegation	$\Pi_i^{(S,N)}, \Pi_j^{(S,N)}$	$\Pi_i^{(S,S)}, \Pi_j^{(S,S)}$	$\Pi_i^{(S,F)}, \Pi_j^{(S,F)}$
	Full Delegation	$\Pi_i^{(F,N)}, \Pi_j^{(F,N)}$	$\Pi_i^{(F,S)}, \Pi_j^{(F,S)}$	$\Pi_i^{(F,F)}, \Pi_j^{(F,F)}$

Figure 4.1. Payoff Matrix

There are three Nash equilibrium strategy profiles (yellow cells) to this delegation game: (N, N) , (S, S) and (F, F) . These correspond to the symmetric cases we have treated, which to some extent verify the reason “why we just focus on the symmetric cases in aforementioned section”. On occasion, however there are situations where even with multiple Nash equilibria, one of them does in fact stand out as the “right” prediction. It seems clear that both firms will choose Semi-Delegation (S, S) , as it is in their mutual interest (Result 17). The equilibrium $(Semi-Delegation, Semi-Delegation)$ Pareto dominates $(No Delegation, No Delegation)$ and $(Full Delegation, Full Delegation)$.

4.7 Concluding remarks

This framework focuses on the issue of strategic delegation in the presence of both endogenous product (horizontal and vertical) differentiation and endogenous R&D spillovers. And the results of this model provide important implications for the real practice of delegation. Within this framework, the linear combination of firm’s

profit and its market share is regarded as managers' objectives, and the owners decide the firm's location pattern and whether to delegate the tasks (such as R&D investment, price) or not.

Existing literature regarding strategic delegation with R&D, considers that firm's owners alternative decisions are either Full Delegation or No Delegation. We introduce the scenario "Semi-Delegation" where firms' owners delegate the short-run decisions and retain the long-run decisions themselves. Our analysis shows that Semi-Delegation encourages one firm to locate farther from the rival and the firms could locate at the two respective extremities of the market. Semi-Delegation increases product differentiation, fosters firms to spend more on R&D, encourages firms to produce high-quality goods and renders managers less aggressive, hence increases prices and profits. However, both consumer surplus and social welfare decrease. By contraries, Full Delegation can improve the social welfare, and it is more profitable than No Delegation. In a more general way, by taking into account all possible subgames, it is shown that both firms' Semi-Delegation is *Pareto* dominant for the firms.

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.

General Conclusion

This thesis has been devoted to the study of inorganic M&As and organic R&D with spillovers. Besides the organic and inorganic research lines, there are two important roadmaps which highlight the research project of this booklet. The first one refers to public authorities. Why do mergers fail to increase profits or welfare? And since they do, what should the merger policy do about it, and moreover what can it really do? What standard should antitrust analysis use to evaluate alternative outcomes? Which timing of antitrust intervention should be implemented?

The second roadmap emphasizes the knowledge. Of course, spillovers are the unintentional transmission of knowledge to others beyond the intended boundary. At every possible interaction, there is a potential for knowledge exchange. If knowledge is exchanged with the intended organizations, it is “knowledge transfer”, any knowledge that is exchanged outside the intended boundary is spillover. Companies can exchange knowledge that is explicit in form of technologies, documents, products or processes.

Public authorities roadmap

There has been considerable debate concerning whether consumer surplus or total surplus should be the welfare standard for antitrust. Williamson (1968) argues that the total surplus standard can make a very big difference in evaluating mergers that give rise to production efficiencies. Furthermore, some contributions³¹

³¹See, for example, Bork (1966) argued that Congress intended a total surplus standard, which he confusingly called a “consumer welfare” standard; Lande (1982, 1999) have argued that Congress intended a true consumer welfare standard under which the Sherman Act would facilitate wealth transfers from producers to consumers; Salop (2005) argues that the current standard is a consumer surplus standard, basing his argument, in part, on the claim that effi-

contrast the consumer welfare and total welfare standards. However, others argue that they are nearly equivalent in a long-run perspective because short-run profits spur firms to serve consumers' long-run interests. This attempt to defuse the debate fails, because even if changes in consumer and total surplus approximately coincide in the very long run, antitrust probably cannot (and surely does not) conduct a very-long-run analysis to evaluate a specific case. An analysis with a shorter time horizon (in practice, often two years) may well predict that consumer and total surplus will move in opposing directions. For instance, in the Canadian *Propane*³² case, the court apparently believed that the merger should be approved under a total welfare standard and blocked under a consumer welfare standard.

The rationale, market consequences and antitrust treatment of mergers represent topical issues for economic research. The essays in this dissertation provide further insight into these questions, from a purely theoretical point of view.

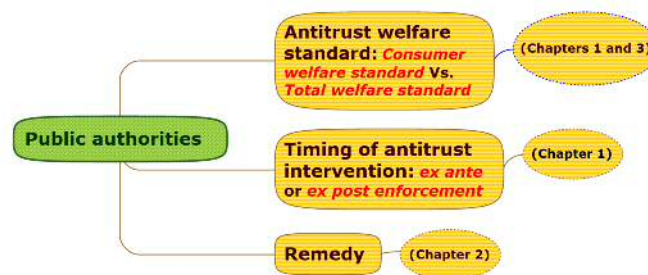


Figure 4.2. Public authorities outline

The first chapter examines the individual private incentives to merge and some of the welfare consequences of such a decision, focuses on the different types of merger and Competition Authorities so as to draw inference on the design of merger

ciencies play little role in the actual practice of merger policy.

³²Commissioner of Competition v. Superior Propane, Inc., (2003) 3 F. C. 529 (Fed. Ct. App.). See Thomas Ross and Ralph Winter, *The Efficiency Defense in Merger Law: Economic Foundations and Recent Canadian Developments*, 72 ANTITRUST LAW JOURNAL (2005) 471-503.

control. Thanks to this chapter, we get the following points of interest:

- *The profitable merger between leaders is necessarily welfare-improving. It provides support for a laissez-faire policy if the decisive criterion rests on social welfare. By contrast, Competition Authorities must supervise more closely bilateral mergers which are consisted of either one or two followers.*
- *When Competition Authorities adopt ex ante enforcement, antitrust enforcers have less information about the merger, the consumer welfare standard is more restrictive than aggregate welfare standard. By contrast, when Competition Authorities choose ex post enforcement, they are aware of the real cost of merged firm, the consumer welfare standard is more lenient than aggregate welfare standard.*

Consistent with what happens in most countries, the second chapter assumes that the foreign firm must notify entry project to the host government, which can either authorize or block the foreign firm's plan. The agencies (or regulators) negotiate settlements with private parties and courts may impose remedies. A sensible candidate might be to turn a profitable, yet welfare-reducing, merger (or entry mode) into a somewhat less profitable but welfare-enhancing one. For instance, in the naive manner, the host government decision is taken in order to approve the entry strategy enhancing the most welfare of host country and to prevent the entry modes less welfare-improving. The social welfare of host country is affected by the consumer surplus and the producer surplus defined by the sum of domestic firms' profits. The study of the interaction between the foreign firm and the host government which is regarded as a screening device to foreign firm's entry choice. The clash between the foreign firm's equilibrium choice and the host government's preference in terms of host country welfare can provide a rationale for some frequently observed market access restrictions.

The third chapter takes into account consumer welfare standard and total welfare standard to examine whether the merger prohibited under the former standard can be authorized under the latter standard. We derive the similar results "*the looseness (leniency) of total welfare standard and the preciseness (restrictiveness)*

of consumer welfare standard” as claimed in the first chapter.

Knowledge roadmap

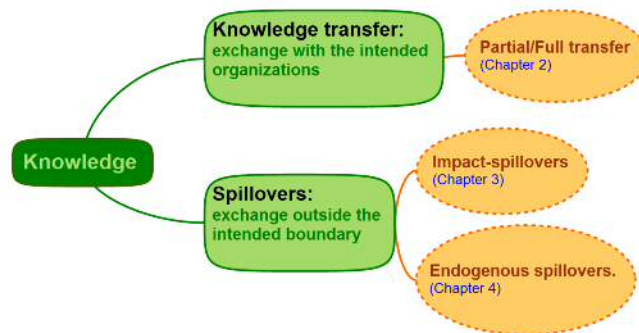


Figure 4.3. Knowledge outline

The second chapter studies the process of technology transfer³³ that happens when a high-technology foreign firm chooses different entry modes to penetrate into developing countries. Both greenfield and brownfield FDI can generate the flow of knowledge from the holder to the receivers. Foreign firm firstly makes a entry choice decision, and then makes the target decision as to who this knowledge is to be shared with. It is worthwhile to note that the greenfield FDI gives rise to the full transfer, by contraries, brownfield FDI leads to the partial transfer due to the post-acquisition integration problem³⁴. Chapter 2 shows that the foreign firm being technologically advantaged, has a stronger incentive to choose brownfield, rather than greenfield investment or export, moreover, it prefers acquiring the low-productivity target because of the knowledge-flow advantage.

³³For instance, when a US company sets up an R&D lab in a developing country for the purpose of transferring knowledge to local engineers and scientists, that is a case of technology transfer and not a spillover.

³⁴According to Hennart (1988), the post-acquisition integration problem can be neglected for the greenfield entry mode, but should be pinpointed for the cross border M&A.

In chapter 3, we analyze the “Impact-spillovers” affected by product differentiation and technological proximity. Firms would be more likely to conduct research in common areas when they manufacture homogenous goods, because producing similar goods usually demands parallel technical solutions or common inputs. The common research enables competing firms to realize more technological opportunities. In addition, similar production processes allow firms to adapt the technological know-how they learn from one another to their own needs. This avenue is also exploited by other economists, such as absorptive capacity (Cohen and Levinthal, 1990), *ex ante* adaptability and *ex post* information sharing (Katsoulacos and Ulph, 1998).

Chapter 4 embraces the notion of endogenous spillovers. The extent of spillover is determined by the distance between firms, which is chosen by firms in upstream stage. Spillovers at local level create a centripetal force that relaxes the incentive to maximal location/product differentiation. In the location-quality-price game, the effects of different strategic delegations on the short-run price, the long-run R&D investment, the private profit and the social welfare are analyzed. This framework can be regarded then as a first step in integrating the R&D/spillovers, the location/product differentiation and the partial/full delegation literatures and points out to the direction of re-examining many previous results obtained in the literature in the absence of location concerns and spillover endogeneity.

Future work

This dissertation also has certain weaknesses and possible extensions. Some of these have already been mentioned in the concluding remarks of previous chapters. The future work aims to following the extensible paths and ameliorating the models. Since empirical work in IO has evolved dramatically and has diffused widely into merger reviews and antitrust litigation, regulatory decision-making, price-setting by firms, design of cooperation. . . we will try to focus on the testing of the results derived by our theoretical frameworks, and making prediction for the core question of IO, by the empirical avenue.

Stackelberg mergers under cost uncertainty

A.1 Best response function of followers

In the follower production stage. The optimizing question is:

$$\max_{q_O^{f,A}} \pi_O^{f,A} = (p^A - c)q_O^{f,A} = [a - c - Q_O^{-f,A} - q_O^{f,A} - Q_O^{l,A}(c) - q_I^{l,A}(c_i)]q_O^{f,A}(c_i) \quad (\text{A.1})$$

From the standpoint of information structure,

- $Q_O^l(c)$: outsider-leaders consider that the cost level of insider is equal to c
- $q_I^l(c_i)$: first-to-know
- $q_O^f(c_i)$: outsider-followers observe the production level and perfectly infer the cost level of merged entity c_i

the *FOC* (first-order-condition) is

$$2q_O^{f,A} = a - c - Q_O^{-f,A} - Q_O^{l,A}(c) - q_I^{l,A}(c_i)$$

perfect symmetry for outsider-followers:

$$Q_O^{-f,A} = (n - m - 1)q_O^{f,A}$$

reaction function of outsider-follower is

$$(n - m + 1)q_O^{f,A} = a - c - Q_O^{l,A}(c) - q_I^{l,A}(c_i) \quad (\text{A.2})$$

and note the sum

$$\begin{aligned} Q_O^{f,A} &= (n - m)q_O^{f,A} \\ &= \left(\frac{n - m}{n - m + 1}\right)(a - c) - \left(\frac{n - m}{n - m + 1}\right)(Q_O^{l,A}(c) + q_I^{l,A}(c_i)) \end{aligned} \quad (\text{A.3})$$

A.2 Best response function of leaders and equilibrium output

In the (first) leader production stage, outsider-leaders are not aware of the actual cost of insider, thereby they take into account the expected value c

$$\max_{q_O^{l,A}} \pi_O^{l,A} = (p^A - c)q_O^{l,A} = [a - c - Q_O^{f,A} - Q_O^{-l,A}(c) - q_O^{l,A} - q_I^{l,A}(c)]q_O^{l,A}(c) \quad (\text{A.4})$$

plug the sum of follower quantity *Eq.* (A.3) into *Eq.* (A.4), the maximization problem becomes

$$\max_{q_O^{l,A}} \pi_O^{l,A} = \frac{1}{n - m + 1} [(a - c) - Q_O^{-l,A}(c) - q_O^{l,A}(c) - q_I^{l,A}(c)]q_O^{l,A}(c) \quad (\text{A.5})$$

FOC:

$$2q_O^{l,A}(c) = (a - c) - Q_O^{-l,A}(c) - q_I^{l,A}(c)$$

perfect symmetry for outsider-leaders:

$$Q_O^{-l,A}(c) = (m - 3)q_O^{l,A}(c)$$

reaction function of outsider-leader is

$$(m - 1)q_O^{l,A}(c) = a - c - q_I^{l,A}(c) \quad (\text{A.6})$$

and note the sum

$$Q_O^{l,A}(c) = (m-2)q_I^{l,A}(c) = \frac{m-2}{m-1}(a-c-q_I^{l,A}(c))$$

For insider (merged entity), when insider knows the real cost c_i , the optimizing question is

$$\begin{aligned} \max_{q_I^{l,A}} \pi_I^{l,A} &= (p^A - c_i)q_I^{l,A} = [a - c_i - Q_O^{l,A}(c) - Q_O^{f,A} - q_I^{l,A}(c_i)]q_I^{l,A}(c_i) \\ &= \frac{1}{n-m+1}[(a-c) + (n-m+1)(c-c_i) - Q_O^{l,A}(c) - q_I^{l,A}(c_i)]q_I^{l,A}(c_i) \end{aligned}$$

FOC:

$$2q_I^{l,A}(c_i) = (a-c) + (n-m+1)(c-c_i) - Q_O^{l,A}(c) \quad (\text{A.7})$$

when insider is not informed about the exact cost $E(c_i) = c$

$$\begin{aligned} \max_{q_I^{l,A}} \pi_I^{l,A} &= (p^A - c)q_I^{l,A} = [a - c - Q_O^{l,A}(c) - Q_O^{f,A} - q_I^{l,A}(c)]q_I^{l,A}(c) \\ &= \frac{1}{n-m+1}[(a-c) - Q_O^{l,A}(c) - q_I^{l,A}(c)]q_I^{l,A}(c) \end{aligned}$$

FOC with respect to expected value c is

$$2q_I^{l,A}(c) = (a-c) - Q_O^{l,A}(c) \quad (\text{A.8})$$

then yield

$$q_I^l(c) + \frac{1}{2}(n-m+1)(c-c_i) = q_I^l(c_i)$$

It is straightforward that in case of $c_i < c$, we obtain $q_I^l(c_i) > q_I^l(c)$; otherwise, $q_I^l(c_i) < q_I^l(c)$.

Based on *Eqs.* (A.6), (A.7) and (A.8), it is possible to derive leaders' equilibrium outputs:

$$q_I^{l,A}(c_i) = \frac{2(a-c) - m(n-m+1)(c_i-c)}{2m}$$

$$q_I^{l,A}(c) = \frac{(a-c)}{m}$$

$$q_O^{l,A}(c) = \frac{(a-c)}{m}$$

plugging them into follower's reaction function *Eq.* (A.2), it yields

$$q_O^{f,A}(c_i) = \frac{2(a-c) + m(n-m+1)(c_i-c)}{2m(n-m+1)}$$

and then, we derive the aggregate output

$$Q = q_I^{l,A}(c_i) + (m-2)q_O^{l,A}(c) + (n-m)q_O^{f,A}(c_i)$$

$$= a - \frac{a}{m(n-m+1)} - \left[\frac{1}{2} - \frac{1}{m(n-m+1)}\right]c - \frac{c_i}{2}$$

A.3 Real and expected profits

The profit of *insider*:

$$\begin{aligned} \pi_I^{l,A} &= (a - Q - c_i)q_I^{l,A}(c_i) \\ &= \frac{a^2}{m^2(n-m+1)} + \frac{[m^2 + 2 - m(n+1)]^2(c_i-c)^2}{4m^2(n-m+1)} - \frac{2ac_i}{m^2(n-m+1)} \\ &\quad + \frac{c_i^2}{m^2(n-m+1)} + \frac{a(c_i-c)(\frac{2}{n-m+1} - m)}{m^2} + \frac{c_i(c_i-c)(m - \frac{2}{n-m+1})}{m^2} \\ &= \frac{[2(a-c) - m(n-m+1)(c_i-c)]^2}{4m^2(n-m+1)} \end{aligned}$$

Knowing that $\mathbb{E}[(c_i-c)^2] = \sigma^2$, $\mathbb{E}[c_i] = c$, $\mathbb{E}[c_i^2] = c^2 + \sigma^2$, $\mathbb{E}[c_i - c] = 0$, $\mathbb{E}[(c_i-c)c_i] = \sigma^2$, the expected profit of *insider*:

$$\begin{aligned} \mathbb{E}[\pi_I^{l,A}] &= \frac{(n-m+1)\sigma^2}{4} + \frac{c^2}{m^2(n-m+1)} - \frac{2ac}{m^2(n-m+1)} + \frac{a^2}{m^2(n-m+1)} \\ &= \frac{(a-c)^2}{m^2(n-m+1)} + \frac{n-m+1}{4}\sigma^2 \end{aligned}$$

The profit of *outsider-leader*:

$$\begin{aligned}\pi_O^{l,A} &= (a - Q - c)q_O^{l,A}(c) \\ &= \frac{(a - c)[2(a - c) + m(n - m + 1)(c_i - c)]}{2m^2(n - m + 1)}\end{aligned}$$

and then the expected profit of *outsider leader* is

$$\mathbb{E}[\pi_O^{l,A}] = \frac{(a - c)^2}{m^2(n - m + 1)}$$

The profit of *outsider follower*:

$$\begin{aligned}\pi_O^{f,A} &= (a - Q - c_i)q_O^{f,A}(c_i) \\ &= \frac{[2(a - c) + m(n - m + 1)(c_i - c)]^2}{4m^2(n - m + 1)^2}\end{aligned}$$

the expected value is

$$\mathbb{E}[\pi_O^f] = \frac{(a - c)^2}{m^2(n - m + 1)^2} + \frac{1}{4}\sigma^2$$

A.4 Merger between two followers

Using the similar method (See **Appendix A.1 and A.2**), the equilibrium outputs for followers are resolved on the basis of the following equations:

- $a - (n - m - 2)q_O^{f,B}(c) - Q_O^{l,B}(c) - q_I^{f,B}(c) - c - q_O^{f,B}(c) = 0$ (outsider followers do not realize the insider's real cost)
- $a - (n - m - 2)q_O^{f,B}(c) - Q_O^{l,B}(c) - q_I^{f,B}(c_i) - c_i - q_I^{f,B}(c_i) = 0$ (insider know his own cost level)
- $a - (n - m - 2)q_O^{f,B}(c) - Q_O^{l,B}(c) - q_I^{f,B}(c) - c - q_I^{f,B}(c) = 0$ (insider does not know his own cost level)

The expression of followers' outputs can be found

$$q_O^{f,B}(c) = \frac{(a - c) - Q_O^{l,B}(c)}{(n - m)}$$

$$q_I^{f,B}(c_i) = \frac{2(a-c) - (n-m)(c_i-c) + 2Q^{l,B}(c)}{2(n-m)}$$

$$q_I^{f,B}(c) = \frac{(a-c) - Q^{l,B}(c)}{(n-m)}$$

and then, plugging them into leader's profit function:

$$\max_{q_O^{l,B}} \pi_O^{l,B} = (p^B - c)q_O^{l,B} = [a - c - (n - m - 2)q_O^{f,B}(c) - q_I^{f,B}(c) - Q_O^{l,B}(c)]q_O^{l,B}(c)$$

It is easy to calculate the leader output level:

$$q_O^{l,B}(c) = \frac{a-c}{m+1}$$

Put the expression of q^l into the output for followers, we obtain

$$q_O^{f,B}(c) = \frac{(a-c)}{(m+1)(n-m)}$$

$$q_I^{f,B}(c_i) = \frac{2(a-c) - (m+1)(n-m)(c_i-c)}{2(m+1)(n-m)}$$

$$q_I^{f,B}(c) = \frac{(a-c)}{(m+1)(n-m)}$$

The equilibrium values in terms of price, profit, consumer surplus and social welfare, are displayed in Table 1.1. The other cases (case C and case D) can be resolved by the similar method.

A.5 Merged firm's profit under complete and perfect information ($\hat{\pi}_I^{j,i}$)

$$\hat{\pi}_I^{l,A} = \frac{\left[(a - 2c + c_i) + (c - c_i)[(m-1)n - (m-2)m] \right]^2}{m^2(n-m+1)}$$

$$\begin{aligned}\hat{\pi}_I^{f,B} &= \frac{[a - 2c + c_i + (c_i - c)(n - m)(m + 1)]^2}{(n - m)^2(m + 1)^2} \\ \hat{\pi}_I^{l,C} &= \frac{\left[(a - 2c + c_i) + (c - c_i)[m(n - m) + (n - 2m)] \right]^2}{(m + 2)^2(n - m - 1)} \\ \hat{\pi}_I^{l,D} &= \frac{[a - c + m(c - c_i)][(a - 2c + c_i) + (c - c_i)(n - m)(m + 1)]}{(n - m)(m + 1)^2}\end{aligned}$$

See also in Le Pape and Zhao (2010)

A.6 $\hat{\delta}_{sup}^i$ and $\hat{\delta}_{inf}^i$

$$\begin{aligned}\hat{\delta}_{inf}^A &= -\frac{a - c}{n - m + 1} & \hat{\delta}_{sup}^A &= \frac{(a - c)[1 - m(\sqrt{2} - 1)]}{(m^2 - 1)(n - m + 1)} \\ \hat{\delta}_{inf}^B &= -(a - c) & \hat{\delta}_{sup}^B &= \frac{a - c}{(n - m)(m + 1) - 1} - \frac{\sqrt{2}(a - c)(n - m)}{m^3 - m^2n + mn(n - 1) + n^2 - 1} \\ \hat{\delta}_{inf}^C &= -\frac{a - c}{n - m - 1} & \hat{\delta}_{sup}^C &= \frac{a - c}{(m + 1)(n - m - 1)} - \frac{(a - c)(m + 2)}{(m + 1)^2(n - m + 1)} \frac{1}{\sqrt{n - m - 1}} \\ \hat{\delta}_{inf}^D &= -\frac{a - c}{n - m} & \hat{\delta}_{sup}^D &= \frac{a - c}{m(n - m)} - \frac{(a - c)}{m(n - m + 1)} \sqrt{\frac{n - m + 2}{n - m}}\end{aligned}$$

A.7 $\delta^i W_{sup}$

$$\delta W_{sup}^A = \frac{2 \left(a(-3 + 2m - 2n) + c(3 - 2m + 2n) + m(3 + 4m^2 + 7n + 4n^2 - m(7 + 8n)) \right)}{m(3 + 4m^2 + 7n + 4n^2 - m(7 + 8n))} \sqrt{\frac{(a-c)^2(4m^4 - 4m^3(1+2n) + 8m(1+3n+n^2) + 4(3+4n+n^2) + m^2(-19-4n+4n^2))}{m^2(1+m)^2(3+4m^2+7n+4n^2-m(7+8n))}}$$

$$\delta W_{sup}^C = 2 \left(\frac{(a-c)(2n-2m-1)}{(2+m)(5+4m^2+m(9-8n)-9n+4n^2)} \right) - 2 \sqrt{\frac{(a-c)^2(4m^5 - 12m^4n + m^3(17-8n+12n^2) + m(60-68n+4n^2-8n^3) + m^2(65-17n+16n^2-4n^3) + 4(4-12n+n^2-n^3))}{(2+3m+m^2)^2(1+m-n)(5-m-4m^2+n+8mn-4n^2)}}$$

$$\delta W_{sup}^D = 2 \left(\frac{c(-1+2m-2n)}{(1+m)(m+4m^2-8mn+n(-1+4n))} + \frac{a(1-2m+2n)}{(1+m)(m+4m^2-8mn+n(-1+4n))} \right) - \sqrt{\frac{(a-c)^2(-8+4m^3-21n-12n^2-4n^3-12m^2(1+n)+3m(7+8n+4n^2))}{(1+m)^2(m-n)(1-4m^2-3n-4n^2+m(3+8n))}}$$

Entry mode choice and target firm selection

B.1 General expressions of social welfare

$$\begin{aligned} W^G &= \pi_H^G + \pi_L^G + \frac{1}{2}(q_F^G + q_H^G + q_L^G)^2 \\ &= \frac{61s^2 - 42s + 13}{32} \end{aligned}$$

$$\begin{aligned} W^E &= \pi_H^E + \pi_L^E + \frac{1}{2}(q_F^E + q_H^E + q_L^E)^2 \\ &= \frac{13 - 42s + 61s^2 + 2t - 18st + 5t^2}{32} \end{aligned}$$

$$\begin{aligned} W_{G,L}^M &= \pi_L^G + \pi_H^M + \frac{1}{2}(q_{ML}^M + q_H^M)^2 \\ &= \frac{19 - 70s + s^2(75 + 16\theta + 8\theta^2)}{48} \end{aligned}$$

$$\begin{aligned} W_{G,H}^M &= \pi_H^G + \pi_L^M + \frac{1}{2}(q_{MH}^M + q_L^M)^2 \\ &= \frac{19 - 62s + s^2(99 - 32\theta + 32\theta^2)}{48} \end{aligned}$$

$$\begin{aligned}
W_{E,L}^M &= \pi_L^E + \pi_H^M + \frac{1}{2}(q_{ML}^M + q_H^M)^2 \\
&= \frac{19 - 6st + 3t^2 + 6t - 70s + s^2(75 + 16\theta + 8\theta^2)}{48}
\end{aligned}$$

$$\begin{aligned}
W_{E,H}^M &= \pi_H^E + \pi_L^M + \frac{1}{2}(q_{MH}^M + q_L^M)^2 \\
&= \frac{19 - 30st + 3t^2 + 6t - 62s + s^2(99 - 32\theta + 32\theta^2)}{48}
\end{aligned}$$

B.2 Welfare under different integration ability

Ability of integration	$W_{E,L}^M$	$W_{E,H}^M$
No integration ability ($\theta = 0$)	$\frac{19+75s^2+6t+3t^2-2s(35+3t)}{48}$	$\frac{19+99s^2+6t+3t^2-2s(31+15t)}{48}$
Small ability ($\theta = \frac{1}{4}$)	$\frac{38+159s^2+12t+6t^2-4s(35+3t)}{96}$	$\frac{19+93s^2+6t+3t^2-2s(31+15t)}{48}$
Medium ability ($\theta = \frac{1}{2}$)	$\frac{19+85s^2+6t+3t^2-2s(35+3t)}{48}$	$\frac{19+91s^2+6t+3t^2-2s(31+15t)}{48}$
Large ability ($\theta = \frac{3}{4}$)	$\frac{38+183s^2+12t+6t^2-4s(35+3t)}{96}$	$\frac{19+93s^2+6t+3t^2-2s(31+15t)}{48}$
Maximum ability ($\theta = 1$)	$\frac{19+99s^2+6t+3t^2-2s(35+3t)}{48}$	$\frac{19+99s^2+6t+3t^2-2s(31+15t)}{48}$

Table B.1. Welfare under different integration ability

R&D Appropriability and Products Substitutability

C.1 First-Best

The social optimum R&D effort derive from the First-Best function welfare:

$$W(x_i, x_j, q_i, q_j) = \sum_{i=1}^2 \pi_i(x_i, x_j, q_i, q_j) + u(x_i, x_j, q_i, q_j) - \sum_{i=1}^2 p_i(x_i, x_j, q_i, q_j) q_i(x_i, x_j, q_i, q_j)$$

By backward induction, $q^{FB}(x_i, x_j)$ is the socially First-Best output profile corresponding to x_i and x_j . It is achieved by:

$$q^{FB}(x_i, x_j) \equiv \arg \max_{q>0} W(x_i, x_j, q_i, q_j)$$

Then the First-Best welfare function W^{FB} is defined by:

$$W^{FB}(x_i, x_j) \equiv W^{FB}(x_i, x_j, q^{FB}(x_i, x_j))$$

Finally,

$$\begin{aligned} x^{FB} &\equiv \arg \max_{x>0} W^{FB}(x_i, x_j) \\ &= \frac{A(1 + \gamma^h)}{(1 + \gamma) - (1 + \gamma^h)^2} \end{aligned}$$

C.2 Review of BS (1999)

There are two regimes: the one is Competition where firms compete in both the R&D and the output markets; the other one is Production Cartel where the firms compete in the R&D market but collude in output market. The superscript “C” stands for Competition and “P” signifies Production Cartel.

The game is solved by backward induction and we characterize the equilibrium outcomes of this game.

Competition:

The SGPE values of per-firm R&D effort, output and profit are given by:

$$\begin{aligned} x^C &= \frac{2A}{\theta}(2 - \beta\gamma) \\ q^C &= \frac{\delta A}{\theta}(2 - \gamma)(2 + \gamma) \\ \pi^C &= \frac{\delta A^2 \Delta}{\theta^2} \end{aligned}$$

where $A = a - c$, $\theta = (2 - \gamma)(2 + \gamma)^2 b \delta - 2(1 + \beta)(2 - \beta\gamma) > 0$ and $\Delta = (2 - \gamma)^2(2 + \gamma)^2 b \delta - 2(2 - \beta\gamma)^2 > 0$

In the paper of Brod and Shivakumar (1999) (Henceforth “BS”), the expression of Δ displayed in page 225 is however $\Delta_{BS} = (2 - \gamma)^2(2 + \gamma)^2 b \delta - 2(1 + \beta)(2 - \beta\gamma)^2 >$

0. We have $\Delta - \Delta_{BS} = 2\beta(2 - \beta\gamma)^2 > 0$ that generates the underestimate of the real profit.

Production Cartel:

The symmetric equilibrium of R&D effort, output and profit correspond to the following solutions:

$$\begin{aligned} x^P &= \frac{A}{\Phi}(2 - (1 + \beta)\gamma) \\ q^P &= \frac{2\delta A}{\Phi}(1 - \gamma) \\ \pi^P &= \frac{\delta A^2 \Gamma}{2\Phi^2} \end{aligned}$$

where $\Phi = \gamma + \beta^2\gamma + 4b\delta(1 - \gamma^2) - 2\beta(1 - \gamma) - 2$ and $\Gamma = -4 + 8b\delta + 8b\delta\gamma^3 + 4\gamma(1 + \beta - 2b\delta) - \gamma^2(1 + 2\beta + \beta^2 + 8b\delta)$. As mentioned in BS, the product $b\delta$ can be expressed in the same units as output, they assume $b\delta = 1$ to simplify expressions. And we find whether these two expressions(Φ, Γ) are positive or not depends on the combination of parameters γ and β .

Whereas, BS consider that $\Phi_{BS} = 4(1 - \gamma)(1 + \gamma)^2b\delta - (1 + \beta)(2 - (1 + \beta)\gamma) > 0$ and $\Gamma_{BS} = 8(1 - \gamma)^2b\delta - (2 - (1 + \beta)\gamma) > 0$. Compared to our results, we have $\Phi - \Phi_{BS} = -4b\delta(1 - \gamma^2)\gamma < 0$. It is clear that there is the underestimate on R&D effort and output. These errors due to improper handling generate the distinctive change in the following analysis. Furthermore, BS regard mistakenly Φ_{BS} and Γ_{BS} as the positive terms. Taking Φ_{BS} as an example, we illustrate here Φ_{BS} is negative when

- $\gamma \in (0.927441, 0.927886]$ and $\beta \in (\tilde{\beta}_1, \tilde{\beta}_2)$
- $\gamma \in [0.927886, 1]$ and $\beta \in (0, \tilde{\beta}_2)$

with $\tilde{\beta}_1 = \frac{1-\gamma}{\gamma} - \sqrt{\frac{1-4\gamma-4\gamma^2+4\gamma^3+4\gamma^4}{\gamma^2}}$ and $\tilde{\beta}_2 = \frac{1-\gamma}{\gamma} + \sqrt{\frac{1-4\gamma-4\gamma^2+4\gamma^3+4\gamma^4}{\gamma^2}}$

A reappraisal of the main propositions in BS (1999)

Proposition 1

Since $\Phi_{BS} > 0$, BS claimed the R&D effort in regime Production Cartel is always significant, the firms colluding in output spared no effort to invest in R&D for $0 \leq \beta \leq 1$ and for all $0 \leq \gamma < 1$. In fact, their finding is not true, the crux of the matter is that the Φ could be negative¹ in certain circumscription where the optimum equilibrium R&D effort is meaningless. We find that the member firm of cartel could have no interest in R&D processus when the goods are sufficiently homogenous, precisely $\gamma \in (\hat{\gamma}, 1]$ with $\hat{\gamma} = \frac{(1+\beta)^2 + \sqrt{33-28\beta+6\beta^2+4\beta^3+\beta^4}}{8}$. In this instance, the x^P will be inferior to x^C , then the proposition 1 is not always true.

In addition, BS (1999) claimed that “it is easy to show that as β rises, the difference $x^P - x^C$ declines” in page 226. As a matter of fact, the $\frac{\partial(x^P-x^C)}{\partial\beta}$ could be positive. Whether this gap enlarges or shrinks depends upon the combination of two parameters β and γ . In order to be more legible and intuitionistic, we illustrate this outcome with the following graphic.

¹ $\Phi - \Phi_{BS} = -4b\delta(1 - \gamma^2)\gamma < 0$.

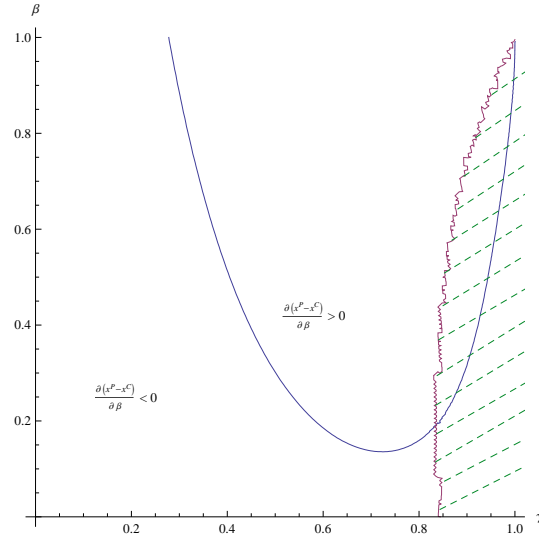


Figure C.1. The effect of β on the difference $x^P - x^C$

On the basis of Figure C.1, apart from the dashed zone which represents the flaw of their proposition 1, we have not only the region, corresponding to the finding of BS, in which the relative valuation of R&D is reduced as spillovers increase, but also the region where the gap enlarges following the rise of spillovers. The primary reason of omitting this positive aspect of β stems from the underestimate of R&D effort in regime P.

Proposition 2

BS (1999) try to compare two mentioned regimes in terms of both individual and collective incentive. They consider output as an index of consumer surplus.

$$\begin{aligned} q^P - q^C &= \frac{2\delta A}{\Phi}(1 - \gamma) - \frac{\delta A}{\theta}(2 - \gamma)(2 + \gamma) \\ &= \frac{A\delta \left(2(1 - \gamma)\theta - (2 - \gamma)(2 + \gamma)\Phi \right)}{\Phi\theta} \end{aligned}$$

It is straightforward $q^P - q^C$ has the same sign as the following expression:

$$f(\gamma, \beta) = \frac{2(1 - \gamma)\theta - (2 - \gamma)(2 + \gamma)\Phi}{\Phi\theta} = \frac{f_{BS}(\gamma, \beta)}{\Phi\theta}$$

Due to improper handling and error of judgement about Φ , it is mistakenly deemed that the difference $q^P - q^C$ has the same sign as the expression $f_{BS}(\gamma, \beta) = 2(1 - \gamma)\theta - (2 - \gamma)(2 + \gamma)\Phi = -2\gamma^4 + (\beta^2 + 2\beta + 3)\gamma^3 - 2\gamma^2(2\beta^2 + 3\beta - 3) - 4\gamma(1 - \beta)$ displayed in page 227. As the case stands, the difference $q^P - q^C$ is also influenced by the denominator $\Phi\theta$.

Concerning the difference of profit $\pi^P - \pi^C$,

$$\begin{aligned}\pi^P - \pi^C &= \frac{\delta A^2 \Gamma}{2\Phi^2} - \frac{\delta A^2 \Delta}{\theta^2} \\ &= \frac{A^2 \delta (\Gamma \theta^2 - 2\Delta \Phi^2)}{2\Phi^2 \theta^2} \\ &\neq \frac{A^2 \delta (\Gamma_{BS} \theta^2 - 2\Delta_{BS} \Phi_{BS}^2)}{2\Phi_{BS}^2 \theta^2}\end{aligned}$$

it is straightforward that $\pi^P - \pi^C$ has the same sign as

$$g(\gamma, \beta) = \Gamma \theta^2 - 2\Delta \Phi^2 \neq \Gamma_{BS} \theta^2 - 2\Delta_{BS} \Phi_{BS}^2$$

According to Figure 2 in BS (1999) page 228, there are always $q_{BS}^P > q_{BS}^C$ and $\pi_{BS}^P < \pi_{BS}^C$ in region D. Practically, we can find the inverse outcome $q^P < q^C$ even $\pi^P > \pi^C$ in this region.

C.3 Deviation payoff

R&D cartel (regime R)

The profit functions of firm i and j are respectively expressed by

$$\pi_i = [a - q_i - \gamma q_j - (c - x_i - \gamma^h x_j)]q_i - \frac{1}{2}x_i^2 \quad (\text{C.1})$$

$$\pi_j = [a - q_j - \gamma q_i - (c - x_j - \gamma^h x_i)]q_j - \frac{1}{2}x_j^2 \quad (\text{C.2})$$

By backward induction, in the second (output) stage, firm i maximizes the individual profit π_i

$$q_i^{R,D} \equiv \arg \max_{q_i} \pi_i$$

then the output of deviating firm is

$$q_i^{R,D}(q_j) = \frac{a - c - \gamma q_j + x_i + \gamma^h x_j}{2} \quad (\text{C.3})$$

At the time of deviation, the quantity level of firm j doesn't change, it remains $q_j(x_i, x_j) = \frac{(a-c)(2-\gamma) - x_i(\gamma-2\gamma^h) + x_j(2-\gamma^{h+1})}{4-\gamma^2}$. Plugging $q_j(x_i, x_j)$ into Eq. (C.3), we have $q_i^{R,D}$ as function of x_i and x_j

$$q_i^{R,D}(x_i, x_j) = \frac{(a - c)(2 - \gamma) + x_i(2 - \gamma^{h+1}) + x_j(\gamma - 2\gamma^h)}{4 - \gamma^2} \quad (\text{C.4})$$

In the first (R&D effort) stage, firm i chooses the R&D investment $x_i^{R,D}$ to maximize its own profit instead of the joint-profit

$$x_i^{R,D}(x_j) = \frac{2(2 - \gamma^{h+1})[(a - c)(2 - \gamma) - (\gamma - 2\gamma^h)x_j]}{8 - \gamma^2[8(1 - \gamma^{h-1}) - \gamma^2(1 - 2\gamma^{2(h-1)})]} \quad (\text{C.5})$$

by contrast, the R&D effort exerted by firm j doesn't alter, and x_j is equal to x^R (see Eq. (3.5)). Put x^R into Eq. (C.5), the R&D effort of deviating firm is

$$x_i^{R,D} = \frac{2(a - c)(\gamma^{h+1} - 2)(2\gamma^{2h+1} + 2(\gamma - 2)\gamma^h - (\gamma(\gamma + 2) - 4)\gamma + 4)}{(2\gamma^{2h} + 4\gamma^h - (\gamma + 4)\gamma - 2)(\gamma(-2\gamma^{2h+1} + 8\gamma^h + \gamma^3 - 8\gamma) + 8)} \quad (\text{C.6})$$

The corresponding deviation output and payoff are derived by plugging Eq. (C.6) into Eq. (C.5) and Eq. (C.1). We get

$$q_i^{R,D} = \frac{(4 - \gamma^2)(a - c)(-2\gamma^{2h+1} - 2(\gamma - 2)\gamma^h + (\gamma(\gamma + 2) - 4)\gamma - 4)}{(2\gamma^{2h} + 4\gamma^h - (\gamma + 4)\gamma - 2)(\gamma(-2\gamma^{2h+1} + 8\gamma^h + \gamma^3 - 8\gamma) + 8)}$$

$$\pi_i^{R,D} = \frac{(a - c)^2(-(\gamma(\gamma + 2) - 4)\gamma + 2\gamma^{2h+1} + 2(\gamma - 2)\gamma^h + 4)^2}{((\gamma + 4)\gamma - 2\gamma^{2h} - 4\gamma^h + 2)^2(\gamma(\gamma^3 - 8\gamma - 2\gamma^{2h+1} + 8\gamma^h) + 8)} \quad (\text{C.7})$$

Production cartel (regime P)

In this regime, firm i deviates in the second (output) stage, thus, it chooses the R&D investment $q_i^{P,D}$ to maximize its own profit instead of the joint-profit.

From the first-condition-order $\frac{\partial \pi_i}{\partial q_i} = 0$, we derive the expression of $q_i^{P,D}(q_j)$ which is the same to Eq. (C.3). At the time of deviation of firm i , firm j doesn't detect, thus the output level of firm j is still determined by maximizing the joint-profit ($q_j = \max_{q_j}(\pi_i + \pi_j)$). Put q_j into expression of $q_i^{P,D}(q_j)$, and then yield

$$q_i^{P,D}(x_i, x_j) = \frac{(a-c)(2-\gamma-\gamma^2) + x_i(2-\gamma^2-\gamma^{h+1}) - \gamma x_j(1-2\gamma^{h-1} + \gamma^{h+1})}{4(1-\gamma^2)} \quad (\text{C.8})$$

In the first (R&D effort) stage, firm i chooses the R&D investment $x_i^{P,D}$ to maximize the individual profit, knowing $x_j = x^P$ (see Eq. (3.3)). The R&D effort of deviating firm is

$$x_i^{P,D} = \frac{(a-c)(2-\gamma(\gamma+\gamma^h))(\gamma(-(\gamma+2)(4\gamma-5)\gamma + \gamma^{2h+1} + (\gamma^2 + \gamma - 4)\gamma^h + 2) - 4)}{(-4\gamma^2 + \gamma + \gamma^{2h+1} + 2(\gamma-1)\gamma^h + 2)(-7\gamma^4 + 12\gamma^2 + \gamma^{2h+2} + 2(\gamma^2 - 2)\gamma^{h+1} - 4)} \quad (\text{C.9})$$

The corresponding deviation payoff is given

$$\pi_i^{P,D} = \frac{(a-c)^2(\gamma(\gamma^{2h+1} + (\gamma^2 + \gamma - 4)\gamma^h - (\gamma+2)(4\gamma-5)\gamma + 2) - 4)^2}{2(\gamma^{2h+1} - 2(1-\gamma)\gamma^h - 4\gamma^2 + \gamma + 2)^2(-\gamma^{2h+2} + 2(2-\gamma^2)\gamma^{h+1} + 7\gamma^4 - 12\gamma^2 + 4)} \quad (\text{C.10})$$

Merger (regime M)

In regime M , firm i deviates in both stages. Beginning with the output stage, the quantity level chosen by deviating firm is the same as Eq. (C.8).

In the R&D effort stage, firm i chooses $x_i^{M,D}$ in order to maximize its profit, knowing that firm j exerts the collusive level $x_j = x^M$ (see Eq. (3.7)). Therefore, the deviating firm's R&D effort level is

$$x_i^{M,D} = \frac{(a-c)(-(\gamma+2)(2\gamma-1)\gamma + \gamma^{2h+1} + (\gamma^2 + \gamma - 2)\gamma^h + 2)(\gamma(\gamma + \gamma^h) - 2)}{(2\gamma - \gamma^{2h} - 2\gamma^h + 1)(-7\gamma^4 + 12\gamma^2 + \gamma^{2h+2} + 2(\gamma^2 - 2)\gamma^{h+1} - 4)} \quad (\text{C.11})$$

The deviation output level for firm i is

$$q_i^{M,D} = \frac{2(1-\gamma^2)(a-c)(\gamma^{h+1} + \gamma^{h+2} + \gamma^{2h+1} - 2\gamma^h - 2\gamma^3 - 3\gamma^2 + 2\gamma + 2)}{(2\gamma - \gamma^{2h} - 2\gamma^h + 1)(4\gamma^{h+1} - 2\gamma^{h+3} - \gamma^{2h+2} + 7\gamma^4 - 12\gamma^2 + 4)} \quad (\text{C.12})$$

The deviation profit

$$\pi_i^{M,D} = \frac{(a-c)^2(-(\gamma+2)(2\gamma-1)\gamma + \gamma^{2h+1} + (\gamma^2 + \gamma - 2)\gamma^h + 2)^2}{2(2\gamma - \gamma^{2h} - 2\gamma^h + 1)^2(7\gamma^4 - 12\gamma^2 - \gamma^{2h+2} + 2(2-\gamma^2)\gamma^{h+1} + 4)} \quad (\text{C.13})$$

It is straightforward that the following condition is satisfied in all scenarios:

$$\underbrace{\pi_i^F}_{\text{Full competition}} < \underbrace{\pi_i^{T,\star}}_{\text{Collusion}} < \underbrace{\pi_i^{D,T}}_{\text{Defection}} \quad \text{with } T = \{R, P, M\}$$

The right-hand inequality means that, from the point of view of single-period payoffs, it is profitable to defect from the collusive strategy. The left-hand inequality means that, from the viewpoint of single-period payoffs, reversion to Full competition is costly compared with adhering to the collusive strategy.

C.4 Critical values of discount factor

$$\bar{\delta}^R = \frac{(\gamma^3 + 2\gamma^2 - 4\gamma - 2\gamma^{h+1} - 2\gamma^{2h+1} + 4\gamma^h - 4)^2}{2(\gamma^6 + 4\gamma^5 - 5\gamma^4 - 28\gamma^3 - 4\gamma^2 + 32\gamma + 48\gamma^{h+2} + 4\gamma^{h+3} - 4\gamma^{h+4} - 16\gamma^{2h+1} + 16\gamma^{2h+2} - 8\gamma^{2h+3} - 4\gamma^{2h+4} - 16\gamma^{3h+1} + 8\gamma^{3h+2} + 4\gamma^{4h+2} - 32\gamma^h + 16)}$$

$$\bar{\delta}^P = \frac{(8(\gamma - 1)^3(\gamma + 1)(2\gamma^2 - \gamma^{h+1} - 1)(\gamma^3 + 2\gamma^2 - 4\gamma - 2\gamma^{h+1} - 2\gamma^{2h+1} + 4\gamma^h - 4)^2)}{S_1 + S_2 + S_3 + S_4 + S_5}$$

$$\bar{\delta}^M = \frac{(2(\gamma + 1)(\gamma^3 + 2\gamma^2 - 4\gamma - 2\gamma^{h+1} - 2\gamma^{2h+1} + 4\gamma^h - 4)^2(2\gamma^5 - 3\gamma^4 + 2\gamma^2 + 4\gamma^{h+1} - 2\gamma^{h+2} + 6\gamma^{h+3} - 2\gamma^{h+4} - 5\gamma^{2h+2} + 2\gamma^{2h+3}))}{S_6 + S_7 + S_8 + S_9 + S_{10}}$$

with

$$\begin{aligned} S_1 &= 16\gamma^{12} + 88\gamma^{11} - 263\gamma^{10} - 728\gamma^9 + 1910\gamma^8 + 1920\gamma^7 - 4540\gamma^6 - 2304\gamma^5 + 4472\gamma^4 + 1280\gamma^3 - 1824\gamma^2 - 256\gamma - 512\gamma^{2h} + 256\gamma^{3h} + 1664\gamma^{h+1} - 256\gamma^{h+2} - 6976\gamma^{h+3} \\ S_2 &= 880\gamma^{h+4} + 8664\gamma^{h+5} - 71\gamma^{2(h+5)} - 1496\gamma^{h+6} - 3648\gamma^{h+7} + 964\gamma^{h+8} + 214\gamma^{h+9} - 110\gamma^{h+10} - 8\gamma^{h+11} - 640\gamma^{2h+1} + 3424\gamma^{2h+2} + 2144\gamma^{2h+3} - 4232\gamma^{2h+4} - 1296\gamma^{2h+5} \\ S_3 &= 734\gamma^{2h+6} - 48\gamma^{2h+7} + 825\gamma^{2h+8} - 112\gamma^{2h+9} - 384\gamma^{3h+1} - 1280\gamma^{3h+2} - 160\gamma^{3h+3} + 496\gamma^{3h+4} + 1080\gamma^{3h+5} + 252\gamma^{3h+6} - 816\gamma^{3h+7} + 198\gamma^{3h+8} + 34\gamma^{3h+9} \\ S_4 &= 128\gamma^{4h+1} + 192\gamma^{4h+2} + 512\gamma^{4h+3} + 48\gamma^{4h+4} - 408\gamma^{4h+5} - 76\gamma^{4h+6} - 124\gamma^{4h+7} + 79\gamma^{4h+8} - 192\gamma^{5h+2} - 160\gamma^{5h+3} \\ S_5 &= 64\gamma^{5h+4} + 64\gamma^{5h+5} + 44\gamma^{5h+6} - 36\gamma^{5h+7} + 32\gamma^{6h+3} + 32\gamma^{6h+4} - 8\gamma^{6h+5} - 2\gamma^{6h+6} + 256 \\ S_6 &= 4\gamma^{12} + 28\gamma^{11} - 23\gamma^{10} - 216\gamma^9 + 150\gamma^8 + 704\gamma^7 - 116\gamma^6 - 848\gamma^5 - 120\gamma^4 + 352\gamma^3 + 128\gamma^2 + 256\gamma^{2h} - 512\gamma^{3h} - 256\gamma^{h+1} - 1088\gamma^{h+2} - 320\gamma^{h+3} + 2576\gamma^{h+4} \\ S_7 &= 1544\gamma^{h+5} - 19\gamma^{2(h+5)} - 1784\gamma^{h+6} + 1000\gamma^{h+7} + 376\gamma^{h+8} + 62\gamma^{h+9} - 42\gamma^{h+10} - 4\gamma^{h+11} + 1280\gamma^{2h+1} + 640\gamma^{2h+2} - 3264\gamma^{2h+3} - 2608\gamma^{2h+4} + 1944\gamma^{2h+5} \\ S_8 &= 1426\gamma^{2h+6} - 188\gamma^{2h+7} + 77\gamma^{2h+8} - 24\gamma^{2h+9} - 512\gamma^{3h+1} + 1728\gamma^{3h+2} + 1344\gamma^{3h+3} - 1248\gamma^{3h+4} - 304\gamma^{3h+5} + 316\gamma^{3h+6} - 244\gamma^{3h+7} + 54\gamma^{3h+8} \\ S_9 &= 18\gamma^{3h+9} - 256\gamma^{4h+1} + 320\gamma^{4h+2} + 544\gamma^{4h+3} - 616\gamma^{4h+4} - 368\gamma^{4h+5} + 188\gamma^{4h+6} - 52\gamma^{4h+7} + 15\gamma^{4h+8} - 256\gamma^{5h+1} - 128\gamma^{5h+2} \\ S_{10} &= 256\gamma^{5h+3} + 16\gamma^{5h+4} - 56\gamma^{5h+5} + 60\gamma^{5h+6} - 20\gamma^{5h+7} + 64\gamma^{6h+2} + 64\gamma^{6h+3} - 32\gamma^{6h+4} - 24\gamma^{6h+5} + 14\gamma^{6h+6} \end{aligned}$$

Appendix **D**

Delegation in a spatial game with endogenous spillovers

D.1 Consumer surplus and Welfare

No Delegation

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

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

Semi-Delegation

$$C_S^S = \frac{\gamma \left(t \left((-5\gamma) \left(t \left(-375\sqrt{5}\sqrt{t^3\gamma^3(5t\gamma+4)} + 75t\gamma(25t\gamma+64) + 1568 \right) - 96v \right) + 4050\sqrt{5}\sqrt{t^3\gamma^3(5t\gamma+4)} + 1888 \right) + 384v \right) - 480\sqrt{5}\sqrt{t^3\gamma^3(5t\gamma+4)}}{96\gamma(5t\gamma+4)}$$

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

Full Delegation

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

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

$$W^F = v - \frac{3t \left(4374t^4 \gamma^5 + 11664t^3 \gamma^4 + t\gamma^2 \left(-459\sqrt{t^2\gamma^2(324t^2\gamma^2 + 504t\gamma + 121)} + 2862t - 3395 \right) - 117\sqrt{t^2\gamma^2(324t^2\gamma^2 + 504t\gamma + 121)} \right)}{100\gamma(9t\gamma + 14)^2} - \frac{t \left(81t^2\gamma^2 \left(-27\sqrt{t^2\gamma^2(324t^2\gamma^2 + 504t\gamma + 121)} + 108t + 754 \right) - 486t\sqrt{t^2\gamma^2(324t^2\gamma^2 + 504t\gamma + 121)} + 945\sqrt{t^2\gamma^2(324t^2\gamma^2 + 504t\gamma + 121)} + 22167t + 4900 \right)}{300(9t\gamma + 14)^2}$$

D.2 Asymmetric cases

Note that there are three possible combinations: 1). No Delegation and Semi-Delegation; 2). No Delegation and Full Delegation; 3). Semi-Delegation and Full Delegation. We restrict the intervals of R&D effectiveness parameter “ γ ” ($\gamma > \frac{163\sqrt{21}}{28}$) and unit transportation cost “ t ” ($\frac{7}{2\gamma} < t \leq \frac{18+2\sqrt{21}\gamma}{75\gamma}$), in order to guarantee the positive values of profit in all asymmetric cases.

No Delegation and Semi-Delegation co-existence

Suppose firm i chooses No Delegation and firm j chooses Semi-Delegation. Both owners firstly fix the locations, and then the R&D investment. After that, owner of firm j decides the contract of manager j to maximize profit. Finally, owner i and manager j make the price decisions simultaneously.

Equilibrium	firm i (No Delegation)	firm j (Semi-Delegation)	Comparison
R&D effort	$x_i^{(N,S)} = \frac{5t\gamma-1}{\gamma(16t\gamma-3)}$	$x_j^{(N,S)} = \frac{6t\gamma-1}{\gamma(16t\gamma-3)}$	$x_i^{(N,S)} < x_j^{(N,S)}$
Contract		$\theta_j^{(N,S)} = \frac{-2t(6t\gamma-1)}{4t(6t\gamma-1)}$	
Price	$p_i^{(N,S)} = \frac{4t(5t\gamma-1)}{\gamma(16t\gamma-3)}$	$p_j^{(N,S)} = \frac{\gamma(16t\gamma-3)}{4t(6t\gamma-1)}$	$p_i^{(N,S)} < p_j^{(N,S)}$
Profit	$\pi_i^{(N,S)} = \frac{(5t\gamma-1)^2(16t\gamma-1)}{2\gamma(16t\gamma-3)^2}$	$\pi_j^{(N,S)} = \frac{\gamma(16t\gamma-3)(8t\gamma-1)}{2\gamma(16t\gamma-3)^2}$	$\pi_i^{(N,S)} > \pi_j^{(N,S)}$

Table D.1. Asymmetric case: No Delegation and Semi-Delegation

By backward induction, we derive the locations of firm i and firm j , which are shown as follow:

$$\begin{aligned}
 y_i^{(N,S)} &= \frac{1 - 2t\gamma(3 + 4t\gamma) + (2t\gamma + 1)\sqrt{16t^2\gamma^2 + 8t\gamma - 7}}{2(1 + t\gamma)} \\
 y_j^{(N,S)} &= \frac{1 + 2t\gamma(3 + 4t\gamma) - (2t\gamma - 1)\sqrt{16t^2\gamma^2 + 8t\gamma - 7}}{2(1 + t\gamma)}
 \end{aligned}
 \tag{D.1}$$

As shown in our framework, we consider that firm locations are restricted to the linear city in order to exclude the potential endogenous spillover problem. Under the restriction of γ and t , it is clear that $y_i^{(N,S)}$ and $y_j^{(N,S)}$ are outside the linear city. Thus, two firms locate at the respective boundaries, namely $y_i^{(N,S)} = 0$ and $y_j^{(N,S)} = 1$. The other relevant equilibrium outcomes, such as R&D effort, contract, price and profit are given in the Table D.1.

No Delegation and Full Delegation co-existence

Assume firm i chooses No Delegation and firm j chooses Full Delegation. In the first stage, owners simultaneously decide the firm locations. And then the owner of firm j designs the incentive contract for manager j . The decision-makers (owner of firm i and manager of firm j) simultaneously decide the R&D efforts by means of different maximization

problems: owner i maximizes the firm's profit, while manager j maximizes the combination of profit and market share. After having taken R&D effort decisions, they continue to decide product prices.

In this asymmetric case, the equilibrium locations are

$$\begin{aligned} y_i^{(N,F)} &= \frac{300t\gamma - 80 - 108t^2\gamma^2 - 243t^3\gamma^3 + (6 + 9t\gamma)\omega}{4(3t\gamma - 2)(14 + 9t\gamma)} \\ y_j^{(N,F)} &= 1 \end{aligned} \quad (D.2)$$

$$\text{with } \omega = \sqrt{(3t\gamma - 2)^2(81t^2\gamma^2 + 72t\gamma - 80)}$$

The incentive scheme chosen by owner j is expressed

$$\begin{aligned} \theta_j^{(N,F)} &= \frac{(3\gamma t + 2)(- (243\gamma^3 t^3) - 216\gamma^2 t^2 + 3\gamma t(3\omega + 68) + 6\omega + 32) (- (19683\gamma^5 t^5) - 4374\gamma^4 t^4 + 243\gamma^3 t^3(3\omega + 148))}{24\gamma(3\gamma t - 2)(9\gamma t + 14)^2(729\gamma^3 t^3 + 648\gamma^2 t^2 + 3\gamma t(15\omega - 332) + 30\omega + 160)} \\ &+ \frac{(3\gamma t + 2)(- (243\gamma^3 t^3) - 216\gamma^2 t^2 + 3\gamma t(3\omega + 68) + 6\omega + 32)(216\gamma^2 t^2(6\omega - 59) + 12\gamma t(45\omega - 848) + 64(82 - 3\omega))}{24\gamma(3\gamma t - 2)(9\gamma t + 14)^2(729\gamma^3 t^3 + 648\gamma^2 t^2 + 3\gamma t(15\omega - 332) + 30\omega + 160)} \end{aligned}$$

The R&D efforts exerted by firm i and firm j are respectively given as follow, and we demonstrate $x_i^{(N,F)} > x_j^{(N,F)}$.

$$\begin{aligned} x_i^{(N,F)} &= \frac{(2 - 3t\gamma)(-39366t^5\gamma^5 + 177147t^6\gamma^6 - 2187t^4\gamma^4(184 + 3\omega) - 2916t^3\gamma^3(-44 + 5\omega))}{3\gamma(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))} \\ &+ \frac{(2 - 3t\gamma)(-432t^2\gamma^2(-209 + 39\omega) - 16(2096 + 99\omega) - 48t\gamma(-766 + 189\omega))}{3\gamma(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))} \\ x_j^{(N,F)} &= \frac{(9t^2\gamma^2 - 4)(33536 + 354294t^5\gamma^5 + 177147t^6\gamma^6 - 6561t^4\gamma^4(-24 + \omega) - 5832t^3\gamma^3(-2 + \omega))}{\gamma(14 + 9t\gamma)(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))} \end{aligned}$$

$$+ \frac{(9t^2\gamma^2 - 4)(1584\omega + 96t\gamma(-1103 + 33\omega) + 216t^2\gamma^2(-622 + 33\omega))}{\gamma(14 + 9t\gamma)(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))}$$

Concerning the prices which firms fix, they are shown respectively

$$p_i^{(N,F)} = \frac{t(2 - 3t\gamma)(-39366t^5\gamma^5 + 177147t^6\gamma^6 - 2187t^4\gamma^4(184 + 3\omega) - 2916t^3\gamma^3(-44 + 5\omega))}{(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))} \\ + \frac{t(2 - 3t\gamma)(-432t^2\gamma^2(-209 + 39\omega) - 16(2096 + 99\omega) - 48t\gamma(-766 + 189\omega))}{(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))}$$

$$p_j^{(N,F)} = \frac{8(-2 + 3t\gamma)(2 + 3t\gamma)(9920232t^6\gamma^6 + 3188646t^7\gamma^7 + 128(961 - 123\omega) + 19683t^5\gamma^5(380 + 3\omega))}{3\gamma(14 + 9t\gamma)^2(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))} \\ + \frac{8(-2 + 3t\gamma)(8748t^4\gamma^4(-370 + 33\omega) + 7776t^3\gamma^3(-712 + 51\omega) + 1296t^2\gamma^2(-900 + 127\omega) + 48t\gamma(19772 + 429\omega))}{3\gamma(14 + 9t\gamma)^2(32 + 216t^2\gamma^2 + 243t^3\gamma^3 + 6\omega + 3t\gamma(-100 + 3\omega))(160 + 648t^2\gamma^2 + 729t^3\gamma^3 + 30\omega + 3t\gamma(-332 + 15\omega))}$$

It is straightforward that the price fixed by firm j with Full Delegation, is higher than the one decided by firm i (No Delegation).

The payoff of firm i

$$\pi_i^{(N,F)} = \frac{(-32 + 3t\gamma(-68 + 9t\gamma)(8 + 9t\gamma) - 3\omega) - 6\omega(32 + 6\omega + 3t\gamma(-76 + 9t\gamma)(16 - 9t\gamma) + 3\omega)^2(32 + 6\omega + 3t\gamma(-268 + 27t\gamma(8 + 9t\gamma) + 3\omega))}{1152\gamma((2 - 3t\gamma)^2(-80 + 27t\gamma(14 + 9t\gamma)) + 15(-4 + 9t^2\gamma^2)\omega)^2} \quad (D.3)$$

is greater than the profit of firm j in which the owner delegate both the short- and long-run decisions to manager.

$$\pi_j^{(N,F)} = \frac{(2 + 3t\gamma)^2(-32 + 3t\gamma(-68 + 9t\gamma)(8 + 9t\gamma) - 3\omega) - 6\omega(16 - 9t\gamma(10 + 9t\gamma) + 3\omega)^2}{128\gamma(14 + 9t\gamma)^2(160 + 30\omega + 3t\gamma(-332 + 27t\gamma(8 + 9t\gamma) + 15\omega))} \quad (D.4)$$

Semi-Delegation and Full Delegation co-existence

In this asymmetric case, firm i just delegates the short-term decision, while firm j delegates both short- and long-term decisions to manager. Since the incentive schemes are chosen sequentially, the contract stage is divided into two steps. Briefly, both firms firstly decide the firm positions, and then firm j chooses the manager's contract, afterwards, owner i and manager j simultaneously decide the R&D investment. After knowing the manager i 's contract designed by owner i , managers fix the product prices individually and simultaneously.

The optimal locations are

$$\begin{aligned} y_i^{(S,F)} &= \frac{6 + 3t^2\gamma^2 + 8t^3\gamma^3 - \xi - t\gamma(17 + \xi)}{(1 - t\gamma)(7 + 4t\gamma)} \\ y_j^{(S,F)} &= 1 \end{aligned} \quad (D.5)$$

with $\xi = \sqrt{(1 - t\gamma)^2(-111 + 48t\gamma + 64t^2\gamma^2)}$

The optimal R&D efforts are

$$\begin{aligned} x_i^{(S,F)} &= \frac{4(1 - t\gamma)(1216t^6\gamma^6 + 512t^7\gamma^7 + t\gamma(1865 - 248\xi) + t^3\gamma^3(257 - 245\xi))}{\gamma(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \\ &+ \frac{4(1 - t\gamma)(-8t^5\gamma^5(183 + 8\xi) - 3(83 + 27\xi) - 3t^4\gamma^4(1143 + 64\xi) - 4t^2\gamma^2(-323 + 71\xi))}{\gamma(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \\ x_j^{(S,F)} &= \frac{8(-1 + t^2\gamma^2)(249 + 1728t^6\gamma^6 + 512t^7\gamma^7 + 81\xi - 8t^5\gamma^5(-153 + 8\xi))}{\gamma(7 + 4t\gamma)(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \\ &+ \frac{8(-1 + t^2\gamma^2)(4t^2\gamma^2(-285 + 11\xi) - 3t^3\gamma^3(21 + 79\xi) + t\gamma(-2033 + 80\xi) - t^4\gamma^4(477 + 256\xi))}{\gamma(7 + 4t\gamma)(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \end{aligned}$$

The optimal contracts are

$$\theta_i^{(S,F)} = \frac{8t(t\gamma - 1)(-249 + 1216t^6\gamma^6 + 512t^7\gamma^7 + t\gamma(1865 - 248\xi) - 8t^5\gamma^5(183 + 8\xi))}{(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \\ + \frac{8t(t\gamma - 1)(-3t^4\gamma^4(1143 + 64\xi) - 4t^2\gamma^2(-323 + 71\xi) - t^3\gamma^3(-257 + 245\xi))}{(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))}$$

$$\theta_j^{(S,F)} = \frac{2(1 + t\gamma)(1 - 7t^2\gamma^2 - 8t^3\gamma^3 + \xi + t\gamma(14 + \xi))(275 + 272t^4\gamma^4 - 64t^5\gamma^5 - 5\xi)}{\gamma(-1 + t\gamma)(7 + 4t\gamma)^2(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \\ + \frac{2(1 + t\gamma)(1 - 7t^2\gamma^2 - 8t^3\gamma^3 + \xi + t\gamma(14 + \xi))(t^5\gamma^3(475 + 8\xi) + t^2\gamma^2(-619 + 51\xi) + t\gamma(-339 + 56\xi))}{\gamma(-1 + t\gamma)(7 + 4t\gamma)^2(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))}$$

The optimal prices are

$$p_i^{(S,F)} = \frac{16t(1 - t\gamma)(1216t^6\gamma^6 + 512t^7\gamma^7 + t\gamma(1865 - 248\xi) + t^3\gamma^3(257 - 245\xi))}{(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))} \\ + \frac{16t(1 - t\gamma)(-8t^5\gamma^5(183 + 8\xi) - 3(83 + 27\xi) - 3t^4\gamma^4(1143 + 64\xi) - 4t^2\gamma^2(-323 + 71\xi))}{(3 + 27t^2\gamma^2 + 40t^3\gamma^3 + 3\xi + t\gamma(-70 + 3\xi))(67t^2\gamma^2 + 104t^3\gamma^3 + 11(1 + \xi) + t\gamma(-182 + 11\xi))}$$

$$p_j^{(S,F)} = \frac{8(\gamma t - 1)(\gamma t + 1)(-825\xi + 4096\gamma^9 t^9 + 23552\gamma^8 t^8 - 512\gamma^7(\xi - 142)t^7 - 48\gamma^6(68\xi - 2865)t^6 + \gamma^5(107723 - 4120\xi)t^5)}{\gamma(4\gamma t + 7)^2(3(\xi + 1) + 40\gamma^3 t^3 + 27\gamma^2 t^2 + \gamma(3\xi - 70)t)(11(\xi + 1) + 104\gamma^3 t^3 + 67\gamma^2 t^2 + \gamma(11\xi - 182)t)} \\ + \frac{8(\gamma t - 1)(\gamma t + 1)(7\gamma^4(997\xi - 10421)t^4 + 8\gamma^3(2457\xi - 25763)t^3 + 4\gamma^2(4412\xi - 29385)t^2 + \gamma(7404\xi + 29141)t + 21855)}{\gamma(4\gamma t + 7)^2(3(\xi + 1) + 40\gamma^3 t^3 + 27\gamma^2 t^2 + \gamma(3\xi - 70)t)(11(\xi + 1) + 104\gamma^3 t^3 + 67\gamma^2 t^2 + \gamma(11\xi - 182)t)}$$

The optimal payoffs are

$$\pi_i^{(S,F)} = \frac{(3047424t^{10}\gamma^{10} + 2359296t^{11}\gamma^{11} + 1936(-55 + \xi) - 3072t^8\gamma^8(2455 + 184\xi) - 88t\gamma(2727 + 265\xi) - 1024t^9\gamma^9(7379 + 288\xi))}{\gamma(-1 + t\gamma)(484 + 341t\gamma + 556t^2\gamma^2 + 192t^3\gamma^3)^2} + \frac{(176t^7\gamma^7(34493 + 11160\xi) - t^2\gamma^2(725903 + 40975\xi) - t^3\gamma^3(1295085 + 83084\xi) + 8t^6\gamma^6(659407 + 89358\xi) + t^4\gamma^4(-1490831 + 131979\xi) + t^5\gamma^5(2203387 + 439712\xi))}{\gamma(-1 + t\gamma)(484 + 341t\gamma + 556t^2\gamma^2 + 192t^3\gamma^3)^2}$$

$$\pi_j^{(S,F)} = \frac{4(1 + t\gamma)^2(20224t^7\gamma^7 + 12288t^8\gamma^8 + t^4\gamma^4(37149 - 428\xi) - t\gamma(-6667 + \xi) + 44(-55 + \xi))}{\gamma(-1 + t\gamma)(7 + 4t\gamma)^2(484 + 341t\gamma + 556t^2\gamma^2 + 192t^3\gamma^3)} + \frac{4(1 + t\gamma)^2(-192t^6\gamma^6(157 + 8\xi) + 3t^3\gamma^3(-1251 + 299\xi) - 4t^5\gamma^5(7325 + 872\xi) - t^2\gamma^2(10711 + 1296\xi))}{\gamma(-1 + t\gamma)(7 + 4t\gamma)^2(484 + 341t\gamma + 556t^2\gamma^2 + 192t^3\gamma^3)}$$

The comparison between firm i with partial delegation and firm j with full delegation are summarized in the following Table.

R&D effort	Contracts	Prices	Profits
$x_i^{(S,F)} > x_j^{(S,F)}$	$0 > \theta_j^{(S,F)}$	$p_i^{(S,F)} < p_j^{(S,F)}$	$\pi_i^{(S,F)} > \pi_j^{(S,F)}$

Table D.2. Semi-Delegation and Full Delegation

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RÉSUMÉ DE LA THÈSE EN FRANÇAIS

Kai ZHAO

Cette thèse est une collection de travaux théoriques sur les effets concurrentiels des stratégies de croissance externe (opérations de fusions-acquisitions) et interne (activités de R&D). Il s'agit de déterminer l'impact de ces deux modes possibles d'expansion sur le comportement des firmes, leur profitabilité et le bien-être social. La thèse est divisée en deux parties principales.

Partie I (effets concurrentiels des stratégies de croissance externe):

On considère que les fusions horizontales génèrent un choc sur le coût des entreprises. Celui-ci se traduit soit par une incertitude sur le coût de production *ex post* de l'entité fusionnée (chapitre 1), soit par un mécanisme de transfert technologique dans une perspective internationale (chapitre 2). Dans le chapitre 1, nous étudions l'impact de l'incertitude sur la profitabilité des stratégies de fusions-acquisitions en considérant un oligopole de Stackelberg. Dans le chapitre 2, nous vérifions si l'option d'entrée par fusions-acquisitions est plus efficace par rapport à d'autres modes d'entrée sur des marchés étrangers, tels que l'Investissement Direct Etranger ou l'exportation.

Partie II (effets concurrentiels de stratégies de croissance interne):

Les efforts R&D ou le bénéfice d'effets de spillovers contribuent à une réduction du coût (chapitre 3) mais aussi à une amélioration de la qualité (chapitre 4). En distinguant les décisions de long-terme (choix en R&D) et des décisions de court-terme (choix en prix ou en quantité), nous étudions l'effet de régimes complets et partiels de collusion dans le chapitre 3. Nous considérons l'impact des choix en R&D sur l'incitation à adopter un régime de délégation partielle ou totale, dans le chapitre 4.

Mots-Clés: *fusions-acquisitions; R&D; incertitude; transfert technologique; investissements directs étrangers; collusion; délégation; régime partiel; spillovers*



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