# Horizontal Mergers: Uncertainty and Internal Organisation

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*A la Magalie*

# Agraïments

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# Introduction

The value of mergers and acquisitions worldwide reached \$3,5 trillion in 2000, a historical record. The fifth and greatest American merger wave in the century (and the first truly global one) had finally peaked. Despite the recent slowdown, the forces driving global consolidation remain very powerful. This surge in merger activity has stimulated an important debate among policymakers, academics and the public about the causes and consequences of these transactions.

The industrial organisation literature has provided a number of explanations as to why mergers occur. Increased market power and economies of scale or scope, for example, should increase the profitability of the merging firms. However, all this neo-classical explanations related to profit-maximising behaviour do not fit well into the data. The empirical evidence on the outcomes of mergers and acquisitions shows that they are hardly ever privately profitable.

Mergers raise some of the more intriguing questions in industrial organisation because many of them have desirable as well as undesirable effects. Mergers between competitors, the so-called horizontal mergers, reduce competition, which may imply welfare losses and transfers of wealth from consumers to producers. Hence, most countries have nowadays competition (antitrust) authorites that scrutinise them. However, horizontal mergers are not illegal per se because they may also generate positive effects for the society, mainly as a result of efficiency gains. Merged firms may reduce production costs thanks, for instance, to a reallocation of production across firms or plants, economies of scale or technological progress.

The work presented in this thesis contributes to the theoretical analysis of the causes and consequences of horizontal mergers. In the first chapter we reconsider the market power-efficiency trade-off and stress the importance of both strategic decision making and internal organisation after mergers take place. In the second and the third chapters, we modify the standard assumption of deterministic product markets to study features that are relevant in more uncertain industries. Since both issues have been neglected by the literature, our contributions may help to improve the design of current merger control systems.

The first chapter broadens the theory on horizontal mergers with efficiency gains in concentrated markets. Most of the literature on horizontal mergers take efficiency gains for granted. In practice, merging firms have strong incentives to overestimate these gains in front of competition authorities. However, the possibility that the merging firms become more efficient does not mean that these gains are actually realised once the operation has been cleared and has taken place. This is because of two related factors. First, becoming more efficient usually requires investment and hence it will be only done when it is profitable. Second, merged firms are not just larger firms but more complex organisations. Mergers bring together two corporate cultures. That may cause conflicts and, as a result, less investment.

The aim of this chapter is to shed more light on how merger and investment decisions interact, and look how the internal organisation of firms influences these interactions. We construct a model of endogeneous merger formation where managers take simultaneously merger decisions. We argue that internal problems may arise at the time where managers decide on investing. Indeed, lack of trust and the impossibility of writing complete contracts may lead to free-riding and suboptimal investments.

We consider two extreme cases: full cooperation or conflict. A lot of mergers take place if managers cooperate internally, despite the fact that possible efficiency gains are not effectively realised. On the other hand, when internal conflict inside firms is foreseen, managers may decide not to merge in the first place. There are, however, profitable mergers that lead to even less efficient firms. Our model gives a potential explanation for merger failures. If the managers underestimate the potential conflict and merge, the new entity could result in a less efficient and profitable firm and thus a failure.

In the second chapter we analyse the positive and normative aspects of horizontal mergers taking into account uncertain and incomplete market information. In contrast, most of the literature assumes that firms have perfect knowledge about the market conditions when taking merger decisions. In practice, this is rarely the case. Indeed, merger decisions are very long term decisions whereas costs or demands change rapidly. For example, oil producers are continuously searching for more cost-efficient oilfields or, biotechnology companies might suddenly discover a highly demanded product. Moreover, firms may or may not observe the outcomes of their rivals. Whereas all firms observe institutional changes that affect costs and demands, the quality of the oilfieds or the latest R&D results are likely to be only privately known. We compare both types of uncertainty, i.e. privately and publicly realised, with deterministic markets.

The purpose of this chapter is to evaluate the information-sharing properties of the horizontal mergers. We show that when the uncertain costs or demands will just be privately observed, firms have more incentives to merge than in deterministic markets. Moreover, as uncertainty increases mergers become more profitable and stable. These results contrasts to the case in which uncertain costs or demands will be publicly observed before competing, where firms may even have less incentives to merge than in deterministic markets. We attribute the difference to the information-sharing properties of horizontal mergers. Our model may partly explain the huge merger activity in the oil and biotechnology industries and, more importantly, why investors rewarded the companies in these industries for getting bigger, while in many other industries mergers and takeovers destroyed value for shareholders.

From the normative point of view, we show that when there will be private information in the market, mergers unambiguously generate an efficiency gain due to the pooling of information and the subsequent rationalisation of production. Mergers that aggregate information are better and may even be welfare enhancing. Instead, when the uncertain parameters will be publicly observed, it is no longer necessary for a firm to merge in order to condition its production to the information possessed by others. Mergers, in this case, may be even worse than in deterministic markets. Again, the difference is due to the information aggregation produced by the mergers.

The third chapter incorporates, in a complete information context, firms' concern about risk in uncertain markets. Several surveys and the extent of the corporate hedging activity suggest that firms are very reluctant to bear product market risk. In a model where firms are risk averse, we analyse the risk-sharing properties of horizontal mergers. Our model fits well, for instance, in the package tours industry. One of its main features is that the attractiveness of travel destinations is uncertain when package tours operators take capacity decisions, i.e. sign contracts with airlines or hoteliers. By merging, package tour operators may diversify away some of the idiosyncratic risk of their respective destination portfolios.

In this setting, merging firms may become more, rather than less, aggressive after the merger. Translated to our example, merging firms may offer more capacity on more destinations after the merger. Thus mergers may not only be more profitable when one considers firms' concern about risk, but they may reduce prices and benefit consumers. More general conditions may need to be introduced, however, before applying this argument as an efficiency defense to, for example, the Airtours/First Choice case.

## Chapter 1

# Mergers, Investment Decisions and Internal Organisation

(This is jointly written with Inés Macho-Stadler and Jo Seldeslachts)

## 1.1 Introduction

Mergers are common practice in many markets and their dynamics, as well as their advantages and disadvantages, are often discussed. Especially the analysis of horizontal mergers and their possible efficiency gains have been important topics in recent years (European Commission Report, 2001). Economic merger theory shows that a merger can reduce welfare by increasing market power but that it can also create efficiency gains in a variety of ways, thereby making the merger possibly welfare enhancing (see Röller et al. (2001a) for an overview).

However, many analysts suspect that there are more factors in play. Efficiency gains of mergers should not be taken for granted. The possibility that a merged firm may become more efficient does not mean that these gains will be actually realised as is now widely assumed in the economics literature. This is because of two related factors. First, becoming more efficient requires investment and is thus a strategic decision. Second, a newly merged firm brings together different corporate cultures, which can lead to conflict and therefore possibly less investment.[1]

[1] A recent example can be found in the creation of Corus in 1999. The Anglo-Dutch group became the third-biggest steel company in the world, but its value has dramatically come down. The Economist (March 15th 2003) argues that the error was that Corus "failed to construct a

This paper broadens the theory on horizontal mergers with efficiency gains in concentrated markets. In line with Rajan and Zingales (1998), we think it is realistic to claim that the manager and not the owner is in control of many decisions that affect a firm's efficiency.[2] The aim is to shed more light on how merger and investment decisions interact, and look how the internal organization of firms has an influence on these interactions. This approach facilitates the understanding of why some mergers may fail to become more efficient or even fail to happen.

We construct a model of endogenous mergers with three managers. Managers choose whom to form partnerships while anticipating a share of the future revenues. Each manager controls some non-transferable resources, such as organizational or managerial capacities, that determine production costs. They have to decide whether to supply them (*invest*) at a private cost before the formed firms compete in the product market à la Cournot. We assume that when managers are together, the resources of the new formed firm add up the resources that the participating managers control.[3] This allows us to take into account economies of scale.[4]

Currently all discussions on mergers are limited to exogenous efficiencies while the outcomes and policy recommendations could be different when considering investment in a more efficient technology as a choice variable. In a study for the European Commission, Röller et al. (2001b) lament the lack of economic knowledge about the interaction of merger and investment decisions: "It is not clear how one should treat the endogenous scale economies that are an alienable aspect of concentrated industries".

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workable model for its internal management, choosing instead to paper over the differences between the English and the Dutch systems."

[2]Rajan and Zingales (1998) say that the amount of surplus that a manager gets from the control of residual rights is often more contingent on him making the right specific investment than the surplus that comes from ownership. Hence, access to the resources of the firm can be a better mechanism to describe power than ownership. Of course the agent who owns and uses the assets of the firm can be the same person.

[3]This argument is valid for all cases where the resources are complementary. The same idea is found in Bloch (1995) Goyal and Moraga-González (2001), where efforts in R&D induce a higher spillover if firms are in a joint venture.

[4]A recent literature on endogenous coalition formation deals with efficiency gains (e.g. Belleflamme (2000), Bloch (1995) and Yi (1997)), but also these authors model efficiency gains as exogenous. Yi (1995) lets firms decide on their investment in R&D, but the level of product market collusion is determined by a social planner.

Forging a common corporate culture out of two or more disparate ones can be costly and can even lead to less efficient and less profitable firms. Surprisingly enough, concepts such as power and conflict within the firm are often forgotten in the economics literature when looking at merger decisions, despite evidence indicating that they play a major role (Seabright, 2000). We consider the possibility that, after a merger, managers do not work in the interest of the firm but in their own.[5] It is often said that the motivation of managers to work together in the interest of the firm comes from team spirit and trust in each other (Kandel and Lazear, 1992). But, this is exactly what we believe is lacking in a merged firm. Since it is not always possible to write complete contracts in a firm and the privately costly investment is ex ante not verifiable, the lack of trust is leading to a free riding problem. Thus, conflict in our model makes that each manager in a firm invests only when it is privately beneficial to do so. Internal problems may therefore arise, driven by a lack of trust and informational externalities caused by the inability to identify individual contributions (Holmström, 1999).

Two extreme cases are considered. First, we analyse the situation where managers cooperate inside the firm when deciding on investment. Equivalently, contracts are assumed to be complete. This setup permits us to investigate what happens when investment is a decision variable and allows us to compare with the realised efficiency gains when managers do not cooperate within the firm. It is found that if managers inside a firm cooperate, they have more incentives to do so in a merged firm because of potential economies of scale, but *only* when it is profitable. In other words, even when there is no internal conflict, a potential merger may not necessarily be more efficient. The second scenario considers a situation where the managers do not trust each other. Contracts are not complete and suboptimal investment decisions are likely to occur (Holmström, 1982). We find that the conflict of interests within the firm can dominate the possible economies of scale, making a larger merged firm invest

[5] All managers in our model stay in the merged firm and keep control over part of the assets. One could claim that in a merger only *one* manager comes to control all the assets. But this would eliminate all internal problems and is normally not observed in reality. Probably it would be better to model a merger not as a conflict between single managers, but as a lack of trust between the different teams that now have to work together. We think that our way of modelling is a good approximation of this idea, assuming that each manager is the boss of his team and making all strategic decisions.

less. A merger can therefore even be a *less* efficient firm than non-merged firms.[6]

These equilibrium investment decisions have an impact on the stability of industry structures. When looking at which mergers will effectively materialise, we find for cooperating managers inside the firm a result in the spirit of Salant et al. (1983). If all managers simultaneously can choose to go to the monopoly industry structure, they will do so. This is possible with our merger stability concept in which managers can anticipate the reaction of the others. Thus, when managers cooperate at the investment-decision level, the only stable structure is the monopoly. This complete market concentration does not necessarily lead to a more efficient production. For non-cooperating managers, not only the monopoly structure but the duopoly and triopoly are possible stable outcomes. Two conclusions follow. First, conflict within the firm can lead to less market concentration, even when modelling mergers as the potentially more efficient firms. This is the case when duopoly or triopoly are stable, whereas without conflict the monopoly was always stable. Second, when there will indeed be mergers in equilibrium, these merged firms are sometimes to be found less efficient. This happens when -despite the internal conflict- it is optimal to merge, but -because of more internal conflict and aggressive investment of competitors- managers invest less in the larger merged firms.

Welfare analysis shows that the stable industry structure is too concentrated from a social point of view for both scenarios when merged firms do not become more efficient. A welfare comparison of the stable structures in the no-conflict and conflict situation indicates that the scenario where managers do not trust each other is always equal or inferior to the case where managers cooperate internally. The cases where the non-cooperating managers do not merge, -leading to less market power and thus better for consumers- are dominated by the loss in efficiency, which is worse for consumers.

[6]The set-up of the model and sequence of events is in the same philosophy as Espinosa and Macho-Stadler (2003), Rajan and Zingales (1998) and Goyal and Moraga-González (2001). In Espinosa and Macho-Stadler (2003), partners group into firms in a sequential way, and in the second stage firms compete à la Cournot with a moral hazard problem inside the firms when deciding upon production. In Rajan and Zingales (1998), an asset owner chooses how many managers can have access to the assets. The managers who receive access choose their non-contractible investment. In Goyal and Moraga-González (2001), firms decide to participate in R&D networks. Given a collaboration network, each firm chooses a non-contractible investment which defines the cost of production and all firms individually compete à la Cournot afterwards.

These results show that interactions between what is happening inside and outside firms is important in determining the boundaries and efficiency levels of a firm. A regulator should take into account that possible efficiency gains of a merger may not be realised, what could change the decision for approval of this merger as we see when analysing social welfare. Possibly there has to be given also more attention to lack of trust within firms. Our model suggests that internal conflict not only harms firms, but also consumers and therefore total welfare. We give as well an explanation for merger failures. When firms decide to go together, the organisational difficulties that this creates are often underestimated. If managers do not correctly foresee the internal problems, the new firm may not be profitable and thus resulting in a failure.

The paper is structured as follows. Section 1.2 describes the model. Sections 1.3, 1.4 and 1.5 present the solutions of the different stages of the model. Section 1.6 analyses merger failures. Section 1.7 and Section 1.8 discuss respectively welfare issues and some extensions of the model. Section 1.9 concludes. All proofs are presented in the Appendix.

## 1.2 Model

We consider a situation where three managers have to decide on their productive organisation. In a first stage, managers decide on the industry structure ($\Omega$) and choose whether to set up their own firm or join forces with other managers. Three industry structures can arise. We denote each manager in a monopoly as $m$ and in a triopoly as $t$. In the duopoly structure, the two managers that merge are denoted by $i$ ('insider') whereas the remaining manager is denoted as $o$ ('outsider'). In the second stage, each manager decides to which extent he invests -at a cost- to reduce production costs. In the first scenario, there is no internal conflict within a firm. Equivalently, all decisions are verifiable and managers behave in the interest of the firm to which they belong. In the second case, their is no control on which managers invest and because of a lack of trust managers do what is best for them individually. In the third stage the formed firms compete à la Cournot.[7]

[7]It is in the interest of all the managers in the same firm to cooperate in the product market. This is because we do not assume that there is an individual cost attached to producing. For a partnership formation model where production is costly for each manager, see Espinosa and Macho-Stadler (2003).

To solve the model we proceed by backward induction. We first solve the third stage of the game, where firms simultaneously decide their production level. We consider an homogeneous market with a linear demand, $P(Q) = a - Q$, where $a$ is a positive constant measuring the size of the market and $Q = \sum_{\omega \in \Omega} q_\omega$ is the total production, with $q_\omega$ the production of firm $w$.

Anticipating the Nash equilibrium in outputs, managers take investment decisions simultaneously. The constant marginal cost of firm $\omega$, $\omega \in \Omega$, will be denoted by $s_\omega$, and consists in common marginal cost, $S$, reduced by the investment of the managers within each firm:

$$s_\omega = S - \sum_{j \in \omega} I_j, \tag{1.1}$$

where $I_j$ represents investment by manager $j$ in firm $\omega$. The more managers in the firm, the more possibility to lower the costs of production, so there are possibilities for economies of scale in investment. Manager $j$ chooses $I_j$ in the set $\{0, k\}$. Parameter $k$ can be interpreted as the magnitude that investment brings in lowering the production costs of the firm.[8] We assume that in equilibrium all firms in all industry structures produce a non-negative quantity and therefore $k \in [0, \frac{a-S}{2}]$. The cost of an investment $I_j$ is denoted by $C_j(I_j)$, where $C_j(0) = 0$ and $C_j(k) = c$.

In the first stage, the merger stage, managers decide on forming a firm alone or together with other managers. We assume firstly that mangers share profits equally, and discuss later that the results would not change qualitatively if they decide on the sharing rule. An industry structure is stable if no manager or group of managers has an incentive to deviate and form a different firm. The payoff of the formed firm depends on the organisation of the other managers. Hence, in evaluating a possible deviation, managers must make a prediction of what the other managers will do. We adopt the view that the most reasonable prediction when deciding upon a deviation is that the remaining managers will choose the best strategy possible.

**Definition 1.1.** *An industry structure $\Omega$ is stable if there is no profitable deviation by a group of managers to form another firm, considering that the remaining managers would choose to form firms to maximise their payoff.*

[8]Note that an alternative approach is to assume that the investment belongs to an interval $[0, k]$. Given the linearity of the model, this would be equivalent to the assumption $I \in \{0, k\}$ since the optimal decision on investment is always a corner solution.

This analysis is relatively simple when considering three managers. When the group considering a deviation is the three-managers firm, we only have to check if this is a profitable deviation since there are no remaining managers. When two managers deviate, the optimal reaction by the third manager is trivially to stay alone. Finally, when only one manager deviates, the remaining two may choose optimally either to go together or to split apart.

When considering a deviation, managers are anticipating the investment outcome in the second stage. When there are multiple Nash equilibria in the investment stage, they have to make a prediction about what will occur as investment outcome. We adopt the view that managers are *optimistic*: when considering a deviation, they predict the investment Nash equilibrium which is most beneficial in terms of profits.[9]

## 1.3 Product market competition (3rd Stage)

Assume that an industry structure $\Omega$ with $r$ firms has been formed at stage 1 and the investments made in stage 2 imply costs $s_v$, for all $v \in \Omega$. Then each firm $w \in \Omega$ maximizes its profits:

$$\max_{q_\omega} \left\{ \left[ a - \sum_{v\in\Omega} q_v \right] q_\omega - s_\omega q_\omega \right\}.$$

The Nash equilibrium of the Cournot game leads firm $\omega \in \Omega$ to produce

$$q_\omega = \frac{\left( a + \sum\limits_{v\in\Omega, v\neq\omega} s_v - r s_\omega \right)}{(r+1)} = \frac{\left( a - S - \sum\limits_{v\in\Omega, v\neq\omega} I_v + r I_\omega \right)}{(r+1)}.$$

[9] This approach has been used by other authors. Diamantoudi (2003) analyses the endogenous formation of coalitions using the concept of 'binding agreements' when there are multiple Nash equilibria and considers different behavioral assumptions, among others the optimistic approach. A similar concept for matching markets has been defined by Demange and Gale (1985). The optimistic view is very demanding in terms of stability since it may induce many deviations. However, in our model with three managers, stability is reached for almost all parameter combinations and this stability concept reduces the number of stable outcomes and allows us to concentrate on 'very' stable industry outcomes.

Without loss of generality we assume $a - S = 1$. The equilibrium (gross) profit for firm $\omega$ is

$$\Pi_\omega = \frac{\left(1 - \sum\limits_{v \in \Omega, v \neq \omega} I_v + r I_\omega\right)^2}{(r+1)^2}. \tag{1.2}$$

## 1.4 Endogenous Investment (2nd stage)

In this section we analyse the investment decision for managers as a function of the market structure and the internal commitment. Let us first set the terminology we use. One of the main aims of the paper is to investigate whether a merger leads to more *efficiency*. We say that there are efficiency gains when a merged firm produces at a lower marginal cost than would separate entities do. This lowering in marginal costs is due to a higher investment of the managers present in the firm.

**Definition 1.2.** *A merger implies* ***efficiency gains*** *when the merged firm has lower production costs. These lower production costs are realised because of a higher investment activity of the managers in the merged firm.*

We consider two extreme cases of internal organisation. First, we discuss the scenario where managers cooperate fully within the firm. This results in the best possible situation for the managers (first best situation). Second, the internal conflict case is looked at.

### 1.4.1 No Internal Conflict

If investment is a cooperative decision within the firm, the profit for a manager $j$ in firm $\omega \in \Omega$ with $|\omega|$ managers is

$$\pi_\omega^j = \frac{1}{|\omega|}\Pi_\omega - \frac{1}{|\omega|}\sum_{l \in \omega} C_l \ . \tag{1.3}$$

Note that maximizing (1.3) is equivalent to maximizing the (net) profits of the firm. Investment of different firms must form a Nash equilibrium.

It is intuitive enough that costs and gains of investment play a major role in what happens in equilibrium and our analysis is done in function of these two parameters.

But apart from costs and gains, the amount in which firms will decide to reduce production costs depends (i) on the size of the firms, i.e. the number of managers in the firm, and (ii), on the competition level. First, the larger a firm is, the more incentives to invest. Since managers in the same firm are cooperating, they will be able to exploit the economies of scale. Second, a firm may want to invest for strategic reasons. Investment activities are strategic substitutes across firms and more investment implies later on a better position in the production phase vis à vis the competitors. Therefore, the more competitors in the market, the more incentives a manager has to invest. This means that the scale effect and strategic effect go in *opposite* directions.[10] Proposition 1.3 states the previous intuition as a function of the parameters of the model. Remark that we state the efficiency gains in the conditional state. At this stage we do not know yet which mergers are going to take place if any.

**Proposition 1.3.** *When managers cooperate, for costs/gains of investment going from low to high, we can distinguish four regions:*
*(A) All managers invest. Any merger would imply efficiency gains.*
*(B) Managers in the monopoly and insiders in a duopoly invest, but single-manager firms may not. Any merger would imply efficiency gains.*
*(C) Managers that set up a firm alone do not invest. Either the monopolists or the insiders invest. There exist therefore always a merger that would lead to efficiency gains, but not any merger would lead to an efficiency gain.*
*(D) Nobody invests. No merger would imply efficiency gains.*

The regions defined in Proposition 1.3 are stated formally in the Appendix and are depicted in Figure 1.[11] When the investment is free (i.e., $c = 0$), any firm will invest in reducing production costs (region A). On the contrary, when the investment is extremely expensive as compared to the cost-production savings, the optimal decision

[10] This is of course an immediate consequence of our model. The number of managers in the market is fixed, so if there are more managers inside the firm -i.e. the firm is larger- there are less managers outside the firm -ie. there are less competitors. However, it seems natural to assume that, *given* a certain industry, larger firms and a more concentrated market go together, even if there would be free entry.

[11] Note that the normalisation $a - S = 1$ implies that $k \in [0, 1/2]$ in order to have all firms producing in equilibrium. Without the normalisation, the axes in Figure 1 would have been: $\frac{k}{a-S}$ and $\frac{c}{a-S}$. Comparative statics with respect to $(a - S)$ would simply expand or contract the figure.

will be not to invest (region D). For intermediate ranges of costs/gains of investment, the scale and strategic issues determine who invests. Region B shows that the first managers to give up investing are the one-manager firms, because the scale event is strongest: the smallest firms loose first their incentives. In region C, both effects can dominate. In region C1, only monopolists invest because the scale effect dominates. In region C2, the strategic motive is more important and the insiders (competeing in the duopoly) invest whereas the monopolists do not. Note that still, *within* the duopoly, the insiders have more incentives to invest than the outsider because of the scale effect. In our model the strategic effects are almost always inferior to the scale effects when there is no internal conflict.

[Insert Figure 1 about here]

Multiple investment equilibria may exist. The optimal decision for a monopoly and duopoly is always unique. In the triopoly the *type* of equilibrium is unique but it is not always clear which manager invests in equilibrium. There are three equilibria of the type $((k)(k)(0))$ where two managers invest, $I = k$, and the third does not. In another region of the parameters there exist three Nash equilibria where the investment decisions take the form $((k)(0)(0))$. This is because managers are ex-ante symmetric and we cannot say who invests and who not. This is not important in the investment stage, since we only need to know what happens in equilibrium, independent on which person does what.

### 1.4.2 Internal Conflict

We now solve the situation where managers within the firm do not cooperate when taking investment decisions. Managers choose again their investment as a function of the gains this investment implies for the profits of the firm to which they belong. But the cost of investing is not shared by the whole firm, the managers *individually* have to bear this cost and a free riding problem might arise. The profit for a manager $j$ in firm $\omega \in \Omega$ with $|\omega|$ managers is

$$\pi_\omega^j = \frac{1}{|\omega|}\Pi_\omega - C_j \ . \tag{1.4}$$

As in the first best case, the amount in which firms decide to reduce production costs depends (i) on the size of the firms and (ii), on the competition structure.

However, the issues are not as clear cut anymore. If a firm is larger, there are still more chances to exploit the economies of scale. But also the possibility for internal conflict grows. In a larger firm each manager receives a smaller share of the gross profits induced by his individually costly investment. The effect of the size of a firm on the incentives to invest can go both ways. Whereas for low costs with respect to gains of investment economies of scale dominates, conflict becomes rapidly more important as costs/gains rise. Thus, managers in larger firms loose much faster their incentives to invest than in the case without conflict. The strategic event still induces managers in a less concentrated market to invest more. It is therefore easy to understand that both the conflict and strategic effect go in the same direction. When conflict is strong, managers in smaller firms -and therefore also facing more competitors- have more incentives to invest. Proposition 1.4 states the previous intuition as a function of the parameters of the model.

**Proposition 1.4.** *When managers do not cooperate inside the firm, for costs/gains of investment going from low to high, we can distinguish four regions:*
*(E) Managers in a monopoly and insiders invest. Any merger would imply efficiency gains.*
*(F) Managers in a monopoly never invest and there is always an equilibrium in which insiders invest. In the equilibrium where insiders invest, a merger towards duopoly would imply efficiency gains. A merger towards monopoly would mean an efficiency loss.*
*(G) Managers in the monopoly and insiders never invest, but there exists always a single-manager firm that does. Any merger would imply efficiency losses.*
*(H) Nobody invests. No merger leads to efficiency gains or efficiency losses.*

The regions defined in Proposition 1.4 are stated formally in the Appendix and are depicted in Figure 2. In region E where the investment is close to free, any firm invests. Within this region conflict is not important, and the scale effect dominates, implying that the largest firms in the market have most incentives to invest. For costs/gains of investment rising, the conflict issue, reinforced by the strategic effect, starts interfering with scale and managers in the monopoly stop investing (region F1). Further on, the conflict situation becomes more and more important, making either the insiders or the outsider in duopoly invest (region F2). The conflict effect becomes finally always dominant and insiders never invest anymore (region G). Finally, when the investment is extremely expensive as compared to the cost-production savings, the optimal decision for all managers will be not to invest (region H).

[Insert Figure 2 about here]

What does this imply for the efficiency gains? As long as the monopolist invests, any merger leads to a more efficient firm. From the moment that managers in the monopoly do not invest and other managers still do, a merger towards monopoly leads to efficiency *losses*. When also the insiders stop investing and the one-manager firm still does, *any* merger leads to efficiency losses. Finally, when nobody invests, a merger does not lead to any efficiency changes.

Summarising the results obtained for both scenarios, some mergers may induce efficiency gains but for this to be true a necessary condition is that the cost of the investment compared to the gains are low enough. If the internal conflict is important, a merger may even imply efficiency losses.

## 1.5 Stable market structures (1st stage)

Managers decide in the first stage to stay alone or go together with other managers, anticipating the investment decisions and competition in the market. We analyse the stable industry structures. We consider first the situation with no internal conflict.

### 1.5.1 No Internal Conflict

When managers cooperate within the firms, larger firms tend to invest more and tend to be more profitable. This makes it naturally more interesting for managers to merge. The next proposition confirms this intuition.

**Proposition 1.5.** *When there is no internal conflict within firms, the monopoly is the only stable structure. No stable structure exists for a region where costs and gains of investment are very low.*

The results stated in Proposition 1.5 are represented in Figure 3. Two different processes lead the monopoly to be the only stable outcome. The first takes place because managers are able to avoid the classical outsider-problem. If a managers tries to free-ride on the others by deviating, the other two *optimally* split apart, making the deviation unprofitable.[12] The other process leads managers very naturally towards the monopoly outcome, because *any* merger is profitable for all managers.

When the cost of investment is high with respect to its gains (region D in the corresponding Figure 1), managers do not invest and the only motive for merging is having more market power. Managers reach thus the monopoly through the first process. However, when the cost of investment is low with respect to its gains (region A), managers always prefer to invest because of economies of scale. Merged entities have therefore lower production costs, leading in general to more incentives to merge than when nobody invests. This situation is similar to the situation described in Perry and Porter (1985), where the merged firm has lower production costs than either of the forming firms.[13] In regions B and C, either the first or the second process makes the monopoly the only stable outcome.

[Insert Figure 3 about here]

### 1.5.2 Internal Conflict

We present the stable mergers when conflict within firms happens. For the sake of presentation, we show the results separately for the four regions identified in Proposition 1.4. Consider first the case corresponding to Proposition 1.4(E) where the cost of investment is low with respect to its gains, making monopolists and insiders always invest.

**Proposition 1.6.** *When there is internal conflict within firms and investment costs/gains are low (monopolists and insiders always invest), the monopoly is the only stable structure.*

[12]The outsider-problem occurs when it is beneficial for all to merge towards monopoly, but it is even better to be the outsider in duopoly. This is the situation in Salant et al. (1983). In their model, where there are no scale economies, merging is beneficial if the number of outsiders is low and the merging firms represent at least 80% of the total market. In our three-firm case this threshold implies the merger towards monopoly.

[13]To be complete, we have to distinguish three different cases when all managers invest. First, for a high enough efficiency gain (a high enough $k$), the monopoly naturally arises. For intermediate gains, managers still prefer to be an outsider over being in a monopoly, but now the other two will prefer to stay together over being alone. There will be therefore continuously a duopoly, but the formed firms are *not stable*. When gains are low, only the merger towards monopoly is profitable and the reasoning is the same as in the case of no investment.

When managers always prefer to invest, entities merge towards monopoly for exactly the same reasons as when managers always invest in the no-conflict situation. These results are depicted in the lower part of Figure 4 (equivalent to region $E$ of Figure 2).

[Insert Figure 4 about here]

The case corresponding to Proposition 1.4(F) is where the conflict effect starts interfering with the scale effect, making the monopoly never investing and there is always an equilibrium in which insiders invest.

**Proposition 1.7.** *When there is internal conflict within firms and costs/gains of investment are intermediate (monopolists never invest and insiders might invest),*
*(a) If in equilibrium the insiders always invest, the duopoly or monopoly can be the unique stable industry structure.*
*(b) If in equilibrium either insiders or the outsider invest, the duopoly is the only stable structure.*

Whenever the gains are high, the duopoly in which the insiders invest is the stable industry structure. The conflict effect induces the monopoly not to invest, but it is still not dominating in the two-player firm, making the insiders in the duopoly the best off (See intermediate part of Figure 4, corresponding to region F1 and F2 of Figure 2). In addition, insiders do not have incentives to split apart: the gains are high enough to prevent them to deviate to triopoly. Hence, duopoly is the stable market structure.[14] Insiders obtain here a higher profit than monopolists. This is an important effect that appears with conflict. When there is no internal conflict, monopoly is always superior to being an insider in duopoly.

When gains are lower and costs of investment higher, the stability arguments are again the same as the situation where all managers invest in no-conflict (its three

[14] In case (b), the investment Nash equilibrium in duopoly is not unique. There is an equilibrium where only the insiders invest and a second where only the outsider invests. When two managers deviate, they are optimistic and expect that in the duopoly structure the Nash equilibrium will be such that they will invest and the outsider will not. They obtain more under this market structure than under triopoly and hence the triopoly is not stable. When deviating from monopoly, the outsider being optimistic, assumes that the final equilibrium is the one in which he invests. However, when the outsider invests, the insiders prefer to break up and to deviate towards triopoly and we have no stability. For the same reason, the outsider-investing duopoly is not stable.

cases also appear here, see footnote 13), but there is an important difference. Here the monopoly does *not* invest. However, even if in this region the monopoly does not invest, the reduction in competition and the lower benefits from investment make the monopoly substantially more beneficial and makes it the only stable industry structure (See region F1 and F2 of Figure 2). A merger to monopoly induces here efficiency losses.

When costs are high with respect to gains, we are in Proposition 1.4(G) and 1.4(H). The conflict effect becomes always dominant and neither monopolists nor insiders invest. When the investment is extremely expensive as compared to the cost-production savings, the optimal decision for *all* managers will be not to invest.

**Proposition 1.8.** *When there is internal conflict within firms and costs/gains of investment are high (only single-manager firms might invest).*
*(a) If only one triopolist invests, the triopoly or monopoly can be the unique stable industry structure.*
*(b) Otherwise, only the monopoly can be a stable industry structure.*

When only one triopolist invests and gains from investment are high enough, it is clear that the triopoly will be the only stable industry structure.[15] In the other cases, monopoly is stable for the same reasons as in region $D$ in Proposition 1.5.

When managers do not trust each other in a newly merged firm, they are less willing to invest, making in turn a merger sometimes unprofitable. Thus, internal conflict generates less mergers, resulting in a completely or partly deconcentrated industry structure. This indicates that even when numerous factors would lead to monopolisation, managers decide not to merge because of a lack of trust. The monopolisation factors are twofold in our model: possible economies of scale and having more market power. Mergers however still occur because of the monopolisation factors, but the lack of trust makes managers often not investing and mergers lead in this case always to efficiency losses.[16]

[15] This triopolist does not want to merge with other managers because of the reinforcing conflict and strategic effects. The other two triopolists do not want to go together either. In a duopoly, the non-investing insiders are in a disadvantage with respect to the investing outsider and moreover, they have to share profits.

[16] Our stability concept has an important role in obtaining monopolisation as a stable industry structure. This equilibrium does not arise in some other merger games. For example, in a model where acquisitions are made through a bidding game, Kamien and Zang (1990) show that monopoly

In the next section we give, based on our model, a possible explanation for merger failures.

## 1.6 Merger Failures

If managers cannot perfectly foresee whether there will be internal conflict within the merged firm, it is possible that wrong merger decisions are taken. Suppose that ex-ante managers merge because they expect a priori that there will be no internal conflict, but conflict does arise later on. This misjudgement might lead to a merger failure (less profits in merger than in no-merger). We have indeed found cases where the monopoly is stable under no conflict (Section 1.5.1) but where in a conflict situation, profits are higher with a lower market concentration (Section 1.5.2), meaning that because of not foreseeing this conflict, managers have erronously merged.

A similar argument applies when managers are rational but there exists uncertainty about the possibility of internal conflict. Let us assume that ex post -in the investment stage- we are in one of our two extreme cases (no conflict at all or total conflict), but ex ante -in the merger stage- managers cannot perfectly foresee what is going to happen. Thus, managers decide upon merging given their expectations:

$$\begin{aligned} \Pr(Conflict) &= \alpha \\ \Pr(NoConflict) &= 1 - \alpha. \end{aligned}$$

Once mergers have occurred, managers realise in which case they are and investment decisions are as described in Section 1.4. We omit the derivation of the stable structures, but the procedure is similar to the two cases presented before.[17] The stable market structures are obtained by calculating with expected profits and are defined by the investment gains ($k$), investment costs ($c$) and expectations ($\alpha$). For illustrating purposes, we depict in Figure 5 the stability results for the case $k = 1/2$.

[Insert Figure 5 about here]

cannot be an equilibrium while making no acquisition at all always is. This occurs because when deviating, a manager in their model assumes that the others will not change their strategy, which is possible in our model.

[17] Calculations are available upon request.

When managers merge to monopoly because they expect the merger to be profitable because the risk of internal conflict is sufficiently low, but there arises a conflict later, there are cases where triopoly or duopoly would have been better choices.[18]

## 1.7 Welfare

In this section we analyse what would be the socially optimal market structure in each situation (with and without internal conflict) and compare these with the obtained stable outcomes. Total welfare is defined as the sum of consumer and producer surplus:

$$W = \frac{Q^2}{2} + \sum_{j=1,2,3} \pi^j.$$

For the consumers, the best solution is where total industry production is highest. Total production is increasing in the level of competition and in firms' efficiency. For both scenarios, when no firm or only the triopolists invest and there are therefore no efficiency gains in merging, production is maximised in the triopoly industry structure. When the monopolists invest and the efficiency gains are important, monopoly is optimal for consumers because the efficiency gains outweigh the market power effects. Duopoly can be output maximising, mostly in the conflict case when insiders in duopoly invest, but managers in the monopoly not.

Looking at the producer surplus, if managers cooperate internally the optimum is always the monopoly. Monopolists are able to replicate or do better what managers do in any other market structure. For non-cooperating managers, total market concentration may not be profit enhancing since conflict may make it impossible for monopolists to replicate what smaller firms do. For example, when the monopolist does not invest but insiders do, it is better to be an insider than a monopolist: the gains in efficiency are higher than the loss of the lower market power. Figure 6 and 7 present the social optimum for both scenarios. In both cases, when costs/gains of investment are low consumers and producers interests coincide and the efficent monopoly is preffered. For cost/gains high, it is unlikely that all managers invest and both groups have opposite interests, but consumer surplus dominates in determining

[18] The opposite can also be true. If managers have a priori pessimistic expectations about the degree of internal conflict and choose not to merge, it may well be ex post that a merger would have been profitable.

what is best for total welfare and the triopoly structure maximises total welfare. For intermediate cost/gains duopoly can be the social optimum.

[Insert Figures 6 and 7 about here]

In comparing the social outcomes (Figures 6 and 7) with the stable industries (Figures 3 and 4), it is clear that when there are important efficiency gains in mergers, the stable outcome is also socially optimal. When the efficiencies are less important, stable market structures are not welfare maximising.

We also see that it is always as good or better for a society when managers cooperate inside the firm. This is of course because investment is more often done, leading to more efficient firms and thus more production. The non-cooperating managers have sometimes less market power in a stable structure, a good thing for consumers, but this coincides always with also less efficient firms, and the latter effect dominates.

We can derive two main conclusions from the welfare analysis. First, when modelling investment as a decision variable, it becomes clear that where stable mergers would be normally good for the total welfare if the -exogenous- efficiency gains are high enough, this is not true anymore, because often merging managers prefer not to invest, even when they are internally cooperating. Second, internal conflict might not only be bad for the managers, but also for consumers, because it is leading to less efficiency and -offsetting the lower market power effect- to less production.

## 1.8 Discussion

In this section we discuss some assumptions of the model. We constructed a model of endogenous mergers in a concentrated market with only *three managers*. We believe that the main effects present would not change in situations with more than three managers. However, with endogenous investment and our stability concept, this analysis would be extremely complex.

We have chosen for simplicity to present throughout the paper the the *sharing rule is exogenous*. Our results qualitatively results qualitatively remain unchanged in a model where the managers optimally decide upon the sharing of the profits when the firm is formed. Note first that it seems natural to assume that when managers are ex ante identical, all the managers in the same firm have to receive ex post the same payoff.[19] Second, the optimal agreement in the conflict case has to maximise the firm's profits taking into account the incentives that this agreement provides. Hence, whether the managers receive their payoff via a fixed fee and/or as a percentage of the joint joint profit determines the incentives to invest. When all the combinations are such that agreeing on an equal sharing rule of the profits induces the same investment decision as in the non-conflict case, this sharing rule is optimal. When the equal sharing does not give incentives in a multi-manager firm, better investment incentives can be obtained by increasing the percentage of the profits to some managers and compensate the others via a fixed fee. When managers set up the optimal payment scheme, the differences between the conflict and no conflict case are smaller because in conflict the investment levels decrease now more gradually.

We have considered two *extreme situations in terms of conflict* within firms. Realistically, there are different levels of conflict where in the firm managers may commit on some $\beta$ is the degree of conflict, managers' profits are $\pi_\omega^j = \frac{1}{|\omega|}\Pi_\omega - \left(\beta C_j + (1-\beta)\frac{1}{|\omega|}\sum_{l\in\omega} C_l\right)$. Again, while having an additional parameter, the analysis would yield similar results.

Finally, we have adopted the view that when deviating, managers are optimistic in the sense that they predict the prevailing equilibrium in investment to be the one in which their profits are highest. This assumption reduces the set of stable market structures, making in some cases the set empty. If managers were pessimistic and hence less willing to deviate, while the set of empty structures may be smaller, we might have situations with multiple stable structures.

## 1.9 Conclusion

The purpose of this paper is to broaden the theory on horizontal mergers with efficiency gains in concentrated markets, including investment as a strategic variable and allowing for a lack of approach facilitates the understanding of why some mergers may fail to become more efficient or even fail to happen. Other merger models take

investment to be exogenous and treat the firm as a black box, but as Holmström (1999) points out, "we cannot claim to fully understand either the internal organisa-

[19] Ray and Vohra (1999) have indeed proven that in a sequential coalition formation game where players are identical this is optimal.

tion of firms or the operation in markets by studying them in isolation".

We construct an endogenous merger formation model with three managers simultaneously taking merger decisions. Internal problems may arise on the moment where managers decide on investing. The lack of trust and inability to identify individual contributions may result in free-riding problems and suboptimal decisions.

We find indeed that even when allowing a merger to be potentially more efficient -i.e., a larger firm can produce at a lower cost when having taken the necessary investment decisions- managers in a merged firm do not necessarily want this to happen. People in a larger firm have effectively more incentives to invest because of of economies of scale, but only do so when this is profitable. The problems due to a lack of trust -becoming bigger in a larger firm- can even offset the possible economies of scale thereby making a merged firm *less* efficient. In a model of strategic R&D networks with Cournot competition in later stage, Goyal and Moraga-González (2001) also find that when R&D is unilaterally chosen, the level of R&D is decreasing in the size of the R&D network.

When managers cooperate internally, we find a complete market concentration to be the only stable outcome. Managers can simultaneously decide together and are able to reach what is for them the best possible industry structure (this is a result similar in the spirit of Salant et al. (1983)). With internal conflict, not only monopoly, but only less concentrated market structures and even a completely defragmentated industry is possible in equilibrium.

Therefore, when managers in the same firm trust each other, all merge, but this merged firm is not necessarily more efficient than firm. When managers do not cooperate internally, they may decide not to internally, they may decide not to merge, because of a too high may invest less than the smaller firms. Whenever a merger is not leading to more efficiency, a move towards more market concentration is leading to efficiency, a move towards more market concentration is leading to lower welfare. Moreover, the lack of trust seems not only to lead to suboptimal outcomes for the managers, but also from a social point of view: the consumers loose more from the loss in efficiency than they gain due to a lower market power of the firms.

With our results, we want to point out that the recent documents on the "efficiency defence of mergers" (see European Commission Report, 2001) are forgetting some essential elements. A regulator should not assume that possible efficiency gains of a merger will be realised, which could change the decision for approval of this merger.

Also, although probably not a generalisable result, the lack of trust in recently merged firms may be important not only for managers, but could also be bad for total welfare, indicating that these issues are as well important for policy makers. Finally, our model also gives an explanation for merger failures. When firms decide to go together, the organisational difficulties that this creates are often underestimated. If managers do not correctly foresee internal problems, they merge while this new entity is not profitable and resulting thus in a failure.

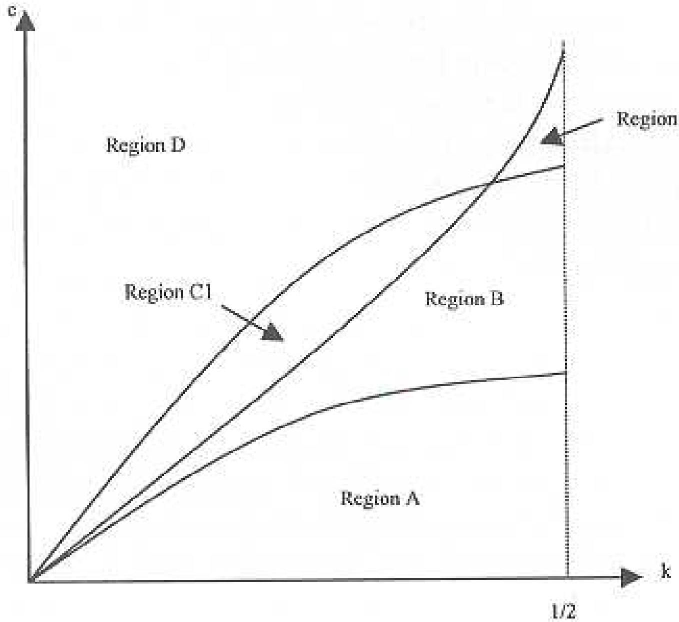


Figure 1: Investment Nash Equilibria when there is no internal conflict.

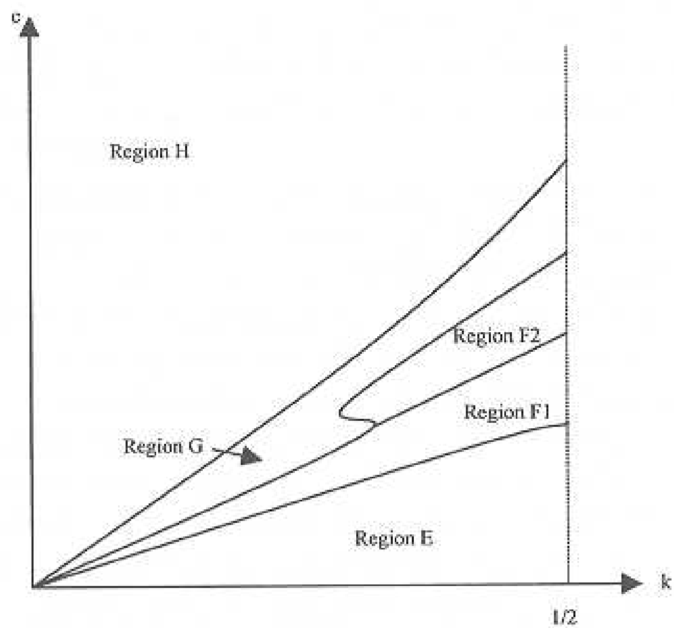


Figure 2: Investment Nash Equilibria when there is internal conflict.

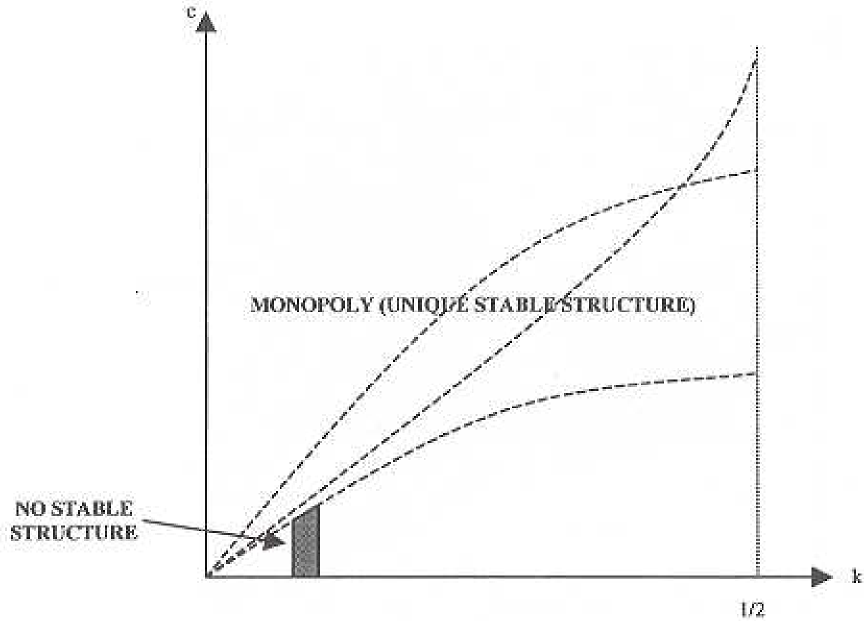


Figure 3: Stable market structures when there is no internal conflict.

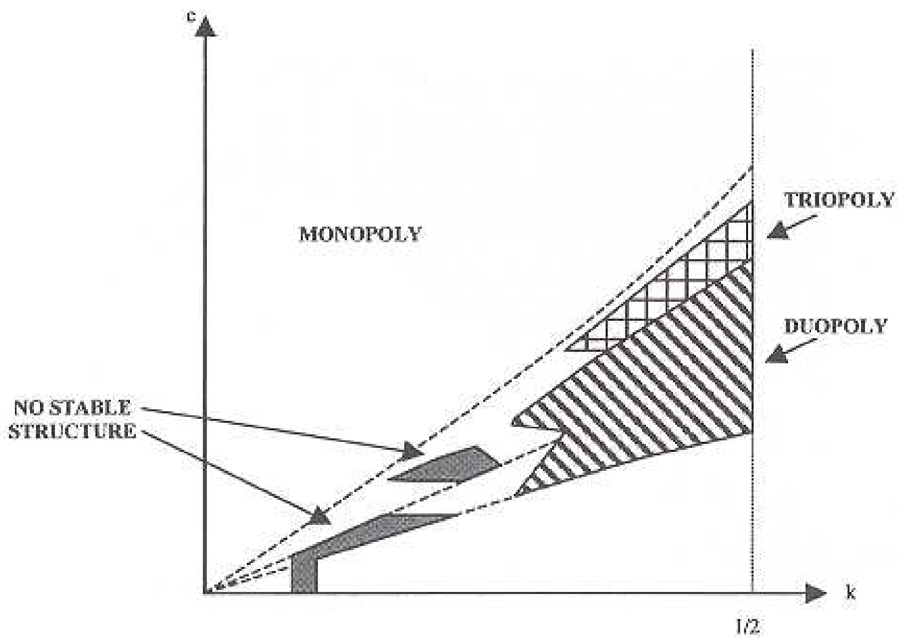


Figure 4: Stable market structures when there is internal conflict.

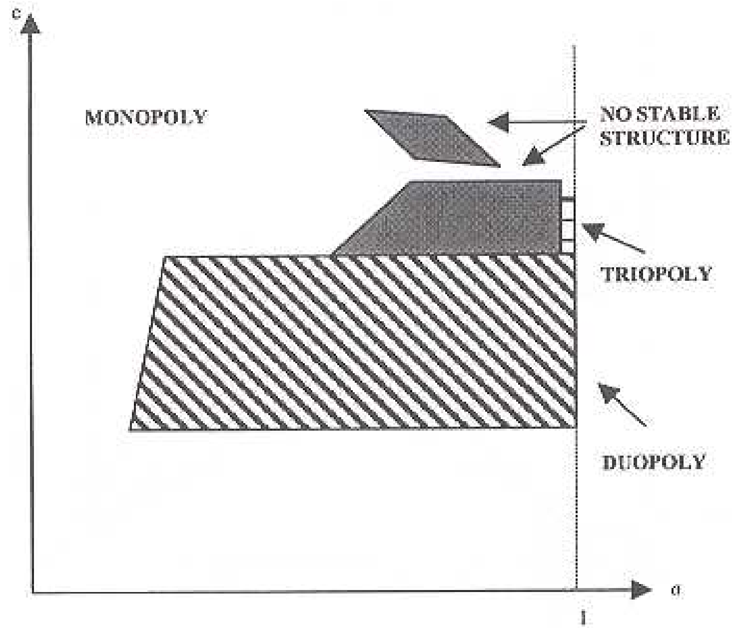


Figure 5: Stable market structures when there is a possibility of internal conflict ($k = 1/2$).

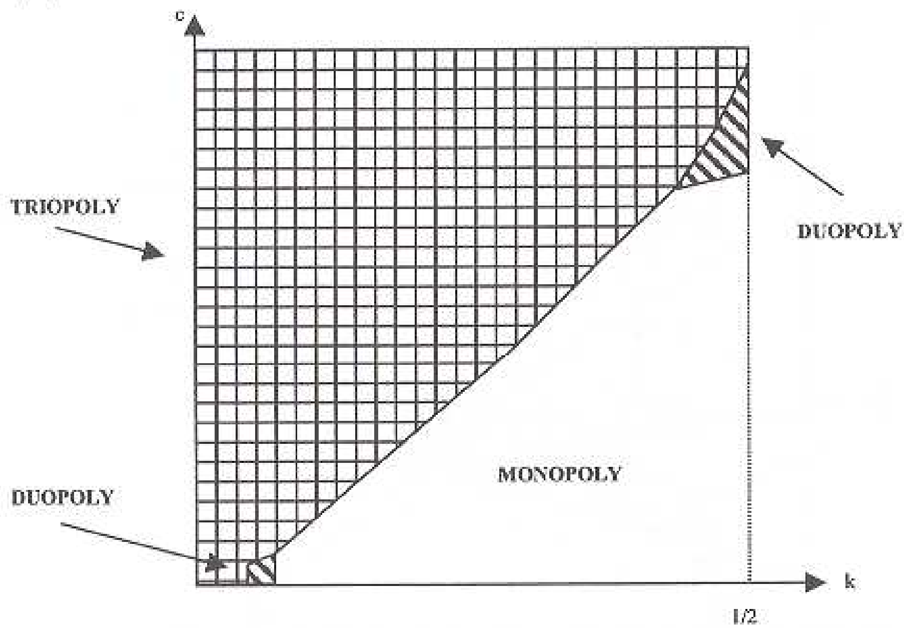


Figure 6: Socially optimal market structures when there is no internal conflict.

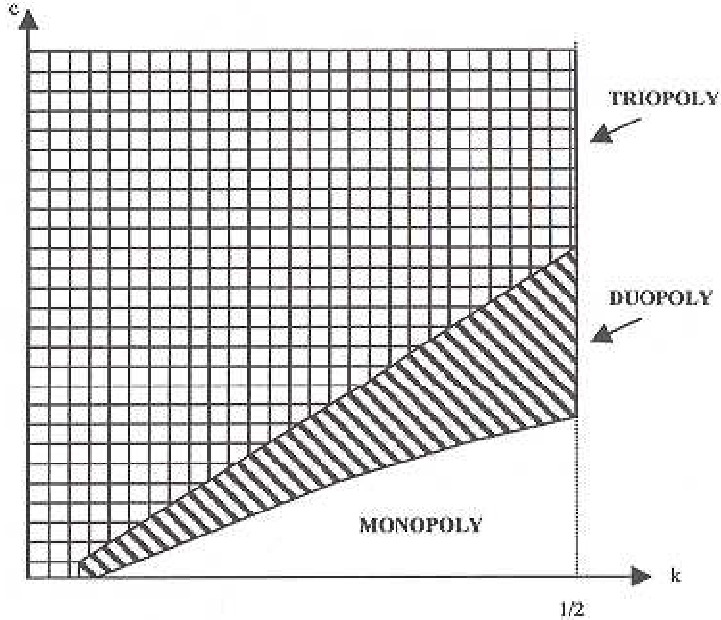


Figure 7: Socially optimal market structures when there is internal conflict.

# Chapter 2

# Information-Sharing Implications of Horizontal Mergers

## 2.1 Introduction

Business commentators argue that market volatility is an important determinant of merger activity. For instance, some claim that the recent wave of consolidation in the oil industry is due to the high uncertainty in the cost of retail production. Increased risks in exploration and high volatility of crude oil prices are cited as important reasons for this sizable merger activity.[1] Similarly, the recent deals in the biotechnology industry have been related to large-scale uncertainty in drug development, and therefore in the resulting product demand.[2] The goal of this paper is to analyze the effects of demand and cost uncertainty on horizontal mergers.

Firms often take long term decisions without knowing all the short term market conditions. In practice, merger decisions are taken while costs and demands are still uncertain. For example, oil companies might find more cost-efficient oilfields or, biotechnology companies might discover highly demanded new products. Accord-

[1] See for example *The Economist*: "Thanks to the rising cost and risk of exploration in ever more remote areas, life has got harder for oil companies. That explains the wave of consolidation of the past three years...big companies are better able to weather the increasing volatility in oil markets." 24/11/01, p. 66.

[2] "There remains a large element of uncertainty in drug development, and to help reduce this the industry is forming alliances and partnerships. Mergers between biotech firms are creating organisations that start to rival the old pharmaceutical companies in scale." *The Economist*, 29/06/02, p. 69.

ingly, we construct a model in which firms fully observe their costs and demands after taking merger decisions. Moreover, firms may or may not observe the outcomes of their rivals. For example, institutional changes affecting costs or demands are publicly observed. In contrast, the quality of new oilfields or the latest R&D results are likely to be only privately known. Our model considers both types of uncertainty and shows that this distinction plays a crucial role.

This paper analyzes the incentives to merge and the welfare effects of mergers in (Cournot) uncertain markets. This is contrasted with the benchmark case of deterministic markets. In the absence of uncertainty, mergers are profitable only if the industry is already very concentrated (Salant et al., 1983 and Perry and Porter, 1985).[3] The reduction in the combined production of the merged firms is compensated by an increase in price only if there are few firms in the market. However, even when industry profits rise, the decrease in total production (and therefore in consumer welfare) is such that mergers in symmetric industries always result in lower social welfare (McAffee and Williams, 1992).

The first contribution of this paper is that firms always have more incentives to merge in uncertain environments if the uncertainty is privately observed. Firms in a merged entity take the information revealed by other insiders into account when making production decisions. This increases the volatility of their individual production, generating losses. However, firms are more aggressive when they belong to a merged entity, cutting production more sharply in the event of a bad signal (and expanding it more in case of a good one). In addition, their output is more closely correlated with market prices. We show that these last two effects dominate the first one and hence firms have more incentives to merge in uncertain environments. Moreover, higher volatility in market conditions enhances merger incentives and, therefore, industry concentration. In contrast to the deterministic case, mergers are also profitable in unconcentrated markets.

The second contribution is that mergers in uncertain environments are socially less harmful if the uncertainty is privately observed. Mergers generate an efficiency gain due to the pooling of information. Total output is produced in a more cost-efficient way. Merging firms react more aggressively, inducing low cost plants to

[3] Salant et al. (1983) study the private incentives in a Cournot model with constant marginal costs whereas Perry and Porter (1985) assume linear increasing marginal costs, as does the model presented here.

produce relatively more than high cost ones. Moreover, when firms merge total output variability drops and consequently social welfare increases (Shapiro, 1986). To summarize, mergers generate informational gains thanks to information aggregation but also welfare losses due to enhanced market power. We show that when the uncertainty is high and the market is not very concentrated, mergers boost social welfare. Indeed, in a symmetric industry, Vives (2002) disentangles private information from market power losses and shows that, for a relatively large number of firms and high levels of uncertainty, welfare losses due to private information are larger than those due to market power.[4]

On the other hand, if the uncertainty is publicly observed, firms do not always have more incentives to merge than in deterministic markets. Although they are more aggressive and their output is more closely correlated with market prices when they merge, the change is lower than in the private information case. Even if the merger does not go ahead, firms will condition the readjustment to the signals of the others. Therefore, the rationalization of output following the merger is weaker and does not always compensate for the loss derived from increased volatility of individual production. Moreover, mergers may be socially worse than in deterministic environments.

Our paper combines elements of two strands of the literature on Cournot oligopoly. On the one hand, the merger literature identifies few merger incentives and negative consequences for social welfare. On the other, the literature on information sharing shows that there are strong incentives for competing firms to share private idiosyncratic information (e.g., cost) and favorable consequences for welfare.[5] In our paper, merging firms share private information and that information can only be shared by merging.[6]

[4]Using a free entry model, he shows that while the effect of market power decays quickly with the number of firms, the effect of private information decays more slowly. Market power (with full or private information) affects the expected price whereas differences due to private information (keeping market power constant) are of a different order because they are driven by variance terms.

[5]See Shapiro (1986), Raith (1996) and Section 8.3 in Vives (1999) for a recent review of this literature.

[6]We assume that the formation of informational coalitions among competing firms is not possible. In practice, such alliances are often illegal (see Kühn and Vives, 1995) or firms' revelation of information can not be verified. In addition, later in the paper, we show that in uncertain environments firms prefer to merge rather than form informational coalitions.

Merger incentives under uncertainty and private information have been studied by Gal-Or (1988). She shows that when firms face a common stochastic demand and receive noisy private signals, they may have less incentives to merge than in deterministic environments.[7] Our model shows, in contrast, that when firms receive perfect signals about different parameters they always have more incentives to merge. Generalizing this model, we recover Gal-Or's result and show that when firms have less incentives to merge in an uncertain environment they would not have merged anyway in a deterministic one. Therefore, even in Gal-Or's context, more mergers would take place in uncertain markets.

The non-academic press often claim that an increase in market volatility leads to a more concentrated industry. Our results consolidate this view by showing that there are greater incentives to merge in more uncertain industries, but only if that uncertainty is characterized by private information. As examples of mergers driven by motives of sharing private information one can cite the oil or biotechnology industries, where firms obtain more information by observing others' oilfields or R& D activities. This may explain the merger activity in these industries and, more importantly, why investors rewarded oil and biotechnology companies for getting bigger, while in many other industries mergers and takeovers destroyed value for shareholders.[8]

The normative findings call for a more careful interpretation of the claims that competition authorities should be more lenient in more uncertain markets.[9] In uncertain markets, mergers unambiguously generate efficiency gains only if there is private information. When the information is public, it is no longer necessary for a firm to merge in order to condition its production to the information possessed by others.

The remainder of the paper is organized as follows. Section 2.2 introduces the basic model and the game for both the private and public information cases. Section 2.3 studies the incentives to merge and the welfare consequences of mergers within uncertain markets when the uncertainty is privately observed. Section 2.4 analyzes the public information case and compares with the private one. Section 2.5 compares

[7] Qiu and Zhou (2002), in a model inspired by Gal-Or (1988), study the private incentives and welfare consequences of a merger between a domestic firm and a foreign firm when the domestic firm knows the demand while the foreign firm is completely uninformed. From the normative point of view, Stennek (2001) considers a model where two duopolists with private cost information merge and studies the effects on price and on consumer welfare.

[8] See *The Economist*, 24/11/01, p. 66 and 27/03/99, p. 76.

[9] For instance, in the European market for third generation (3G) mobile services.

information-sharing mergers with informational alliances. Section 2.6 extends the basic model with private information to an information structure encompassing the private values and common value models. Section 2.7 concludes. All proofs are relegated to the Appendix.

## 2.2 Basic model

### *Setup*

Consider a market for a homogeneous product with linear demand, $D(X) = a - X$, where $a$ is a positive constant and $X$ the consumption level. Let there be $n$ risk-neutral firms, $j = 1, \ldots, n$, producing at cost $C_j(x_j, \theta_j) = \theta_j x_j + \frac{e}{2\kappa} x_j^2$, where $x_j$ is the production, $\theta_j$ a random parameter, $e$ a positive constant and $\kappa$ the firm's capital investment. That is, marginal costs' curves are (linearly) strictly increasing and their slopes are reduced by a larger amount of capital, $MC_j(x_j, \theta_j) = \theta_j + \frac{e}{\kappa} x_j$. As noted by Perry and Porter (1985), increasing marginal costs are crucial for yielding sensible descriptions of mergers. The merged firm is bigger than either of the merging firms because it combines the assets of those firms.[10] In our model marginal costs have random intercepts, $\theta_1, \ldots, \theta_n$. In the basic setup, they are independently and identically distributed with mean $\overline{\theta}$ and variance $\sigma_\theta^2$ in the support $[\theta_{min}, \theta_{max}]$.

### *Merger*

We assume that when firms merge, they set up a new entity that manages these firms as plants. This is equivalent to setting up a bigger firm that owns the capital of the merging firms. Take for example an entity that manages two identical firms, $j$ and $l$, with marginal costs $MC_j(x, \theta) = MC_l(x, \theta) = \theta + \frac{e}{\kappa} x$. The multiplant firm is identical to a single plant firm with marginal costs $MC_{jl}(x, \theta) = \theta + \frac{e}{2\kappa} x$ (Figure 1). Next, take an entity that manages two different firms, $q$ and $r$, with marginal costs $MC_q(x, \theta_q) = \theta_q + \frac{e}{\kappa} x$ and $MC_r(x, \theta_r) = \theta_r + \frac{e}{\kappa} x$ with $\theta_q \leq \theta_r$. This is equivalent to a firm with marginal costs $MC_{qr}(x, \theta_q, \theta_r) = \min\{\theta_q + \frac{e}{\kappa} x, \frac{\theta_q + \theta_r}{2} + \frac{e}{2\kappa} x\}$ (Figure 2). If the new firm produces a small amount, it will use the most efficient plant. If it

[10] With constant (or decreasing) average costs, possibly varying across firms, mergers would lead to the shutdown of all but one firm(s), which is almost never observed in real mergers. Nevertheless, these models are often used because of their simplicity (e.g. Stennek, 2001).

produces a larger amount, it will produce with the two plants or with one plant using double the capital of either of the merging firms.

[Insert Figures 1 and 2 about here]

Denoting $\lambda \equiv \frac{e}{\kappa}$, the profits of an independent firm are

$$\pi_j = (a - X)x_j - (\theta_j + \frac{\lambda}{2}\, x_j)\, x_j, \tag{2.1}$$

while the profits of a merger of $k$ firms are

$$\pi_M = (a - X)(x_1 + \cdots + x_k) - \sum_{i=1}^{k}(\theta_i + \frac{\lambda}{2}\, x_i)\, x_i. \tag{2.2}$$

***Timing of events***

Cost uncertainty is either privately or publicly observed. In order to facilitate the comparison, both cases are studied within the same framework. On the basis of the information sharing literature (see e.g. Shapiro, 1986), consider the following three stage game for the *private information* case: [1] $k$ ($\leq n$) firms decide whether to merge; [2] each firm observes its own costs (a merged firm observes the costs of its insiders); [3] each firm chooses an output level (a merged entity chooses an output level for each plant).[11]

The only commitment device for sharing private information is a merger.[12] Merger decisions are taken prior to the acquisition of information, so issues of incentives to merge when a firm is already aware of its own costs are not considered.[13]

[11] Firstly, we assume that firms take merger decisions before the realization of the uncertainty because they are long term decisions whereas market conditions change rapidly. Moreover, uncertainty outcomes and output choices are likely to be repeated several times in a given period, for example each quarter in a year, whereas decisions to merge are taken once and for all. Secondly, we assume that firms set output decisions after uncertainty realization because we want to study the effects of the asymmetric information. In addition, the uncertainty would not change the incentives to merge (under risk neutrality) if it was realized or observed before.

[12] Insiders have no strategic incentives to conceal or misrepresent information.

[13] In an international context, Das and Sengupta (2002) study the incentives to merge with private information but no uncertainty: the domestic firm is already aware of the demand whereas the foreign firm already knows the production costs.

For the *public information* case, we use the same game with a slight variation in the second stage. Namely, each firm observes the costs of all the firms (and plants) instead of only its own.

### Assumptions

Due to the symmetry at the first stage, it is assumed that the gains of the merged entity are split equally between the insiders.[14] In addition, as in Shapiro (1986) and Vives (2002), it is assumed in order to avoid boundary problems in which some firms or plants are inactive that the underlying parameters are such that for all realizations of the cost parameters each firm finds it optimal to produce a positive amount in each of its plants. This means that the relative inefficiency of firms and plants is never so large as to imply the shutdown of less efficient producers.[15]

### Reinterpretations

The basic model presented admits other interpretations. It can also be interpreted as a Cournot market with product differentiation and constant marginal costs (Vives, 2002). Indeed, the profits of a single-plant firm $j$ can be simply rewritten as $\pi_j = \big(a - (1+\frac{\lambda}{2})x_j - X_{-j}\big)\, x_j - \theta_j\, x_j$. Its inverse demand function corresponds to $d_j = \big(a - (1+\frac{\lambda}{2})x_j - X_{-j}\big)$, with $(1+\frac{\lambda}{2})$ and 1 being, respectively, the own and the cross demand effects. Here $\lambda$ represents the (symmetric) degree of differentiation between the products. When $\lambda = 0$ firms produce homogeneous products and as $\lambda$ increases brands are less related. In this model, the merged entity produces several differentiated products rather than producing a homogeneous good with several plants.

Alternatively, the model can be reinterpreted as a model with (idiosyncratic) demand uncertainty. Indeed, the profits of a single-plant firm $j$ can be rewritten as $\pi_j = (a - \theta_j - (1+\frac{\lambda}{2})x_j - X_{-j})x_j$. Here $\theta_j$ is a random shock to the demand and the firms have constant marginal costs normalized to 0 for the sake of simplicity.

[14] Although it is natural when firms are ex-ante symmetric, this assumption is not necessary for the results. If the merger is profitable in overall terms, the firms will find a sharing rule that satisfies participation constraints.

[15] This condition will impose a restriction in the length of the support of the random variables with respect to the net demand $(a - \overline{\theta})$ for a given number of firms. In turn this will fix an upper bound on the variance. The upper bounds for the private information case are important in our analysis and are derived in Appendix A.

However, in order to clarify the arguments, most of the discussion in the paper is based on the original interpretation of the model.

## 2.3 Uncertainty and private information

This section examines the incentives to merge and the welfare consequences of mergers when uncertainty is privately observed or realized. The first objective is to determine in which market structures mergers will take place. The second is to assess their impact on social welfare.

### 2.3.1 Production and profits

In the third stage, either all firms behave independently or a subset of firms has merged. In both cases, the linear-quadratic model yields unique Bayesian Nash equilibria and the unique equilibrium strategies are affine in the information firms have.

Consider first the case where no merger has occurred. Firm $j$ selects its output $x_j$ after observing its cost $\theta_j$ in order to maximize its profits (2.1). Thus, each firm chooses a linear decision rule of the form

$$x_j(\theta_j) = r_N^D\,(a - \overline{\theta}) - r_N^U\,(\theta_j - \overline{\theta}) \qquad j = 1, \ldots, n, \tag{2.3}$$

where $r_N^D = \frac{1}{n+\lambda+1}$ and $r_N^U = \frac{1}{2+\lambda}$.[16] In equilibrium, firms follow identical decision rules and in particular, $\overline{x}_j = \overline{x}_l \equiv \overline{x}$ for any $j, l$.[17] Notice that the reaction of each firm to the realization of the random cost, the responsiveness $r_N^U$, is independent of the number of firms in the market. Since the shocks are independent, knowledge of own costs does not give any additional information about others. Therefore each firm reacts equally in the presence of more firms.

Consider now the case where $k$ firms merge. The resulting entity, after observing the costs of its plants $\theta_1, \ldots, \theta_k$, selects its output in order to maximize its profits (2.2), whereas the outsiders solve the same problem as before: they maximize (2.1).

[16] $r_N^D$ and $r_N^U$ stand for reaction to the deterministic and uncertain margins when no firm has merged.

[17] As usual, $\overline{s}$ denotes the mean of the variable $s$.

The merged entity produces in each plant $i$,

$$x_i(\theta_1, \ldots, \theta_k) = r_I^D\,(a - \overline{\theta}) - r_I^{U,O}(\theta_i - \overline{\theta}) + r_I^{U,P} \sum_{p=1, p\neq i}^{k} (\theta_p - \overline{\theta}) \qquad i = 1, \ldots, k, \quad (2.4)$$

where $r_I^D = \frac{1+\lambda}{(2k+\lambda)(1+\lambda)+(n-k)(k+\lambda)}$, $r_I^{U,O} = \frac{2(k-1)+\lambda}{\lambda(2k+\lambda)}$ and $r_I^{U,P} = \frac{2}{\lambda(2k+\lambda)}$.[18] The pooling of information allows the new entity to rationalize its production between its plants. Indeed, each plant increases production when it receives a low cost ($r_I^{U,O} > 0$) and when a partner receives a high cost ($r_I^{U,P} > 0$). However, the reaction to its own shock is more aggressive than the reaction to the others' ($r_I^{U,O} > r_I^{U,P}$). Each outsider $o$ produces

$$x_o(\theta_o) = r_O^D\,(a - \overline{\theta}) - r_O^U\,(\theta_o - \overline{\theta}) \qquad o = k+1, \ldots, n, \quad (2.5)$$

where $r_O^D = \frac{k+\lambda}{(2k+\lambda)(1+\lambda)+(n-k)(k+\lambda)}$ and $r_O^U = \frac{1}{2+\lambda}$.

The above expressions allow us to compute the expected profits for each firm. In both market structures, they can be split into two parts. When the merger does not take place in the first stage, expected profits are identical, $E(\pi_j) = E(\pi_l) \equiv E(\pi_N)$ for any $j, l$. Taking expectations in (2.1) and rewriting, $E(\pi_N) \equiv g_N^D + g_N^U$ where

$$g_N^D = (a - \overline{X})\overline{x} - (\overline{\theta} + \frac{\lambda}{2}\,\overline{x})\,\overline{x}, \quad (2.6)$$

and

$$g_N^U = -E[(x_j - \overline{x})(X - \overline{X})] - E[(x_j - \overline{x})\,(\theta_j - \overline{\theta})] - \frac{\lambda}{2}E[(x_j - \overline{x})^2]. \quad (2.7)$$

$g_N^D$ represents the expected profits that would arise in the equivalent deterministic market i.e. if the output of each firm was always $\overline{x}$ and produced at cost $\overline{\theta}$. $g_N^U$ represents the extra expected profits derived from the uncertainty. The first term in $g_N^U$ is the negative covariance between total output and firm's output. As correlation decreases expected profits rise. Indeed, when the ex-post individual production turns to be large, a lower correlation implies that the total output is lower and the price higher. By contrast, when the ex-post individual production proves to be low the price is lower. Ex-ante, the expected price per unit becomes higher as correlation falls. The second term is the negative covariance between firm's production and its marginal

[18] $r_I^{U,O}$ and $r_I^{U,P}$ stand for reaction to own and partners' shocks.

costs intercept. Expected profits increase when the reaction to the random shock is stronger because the cost per unit is lower. Finally, the last term is the negative variability of firm's output. Firms have increasing marginal costs and therefore higher costs when they produce large quantities.

Similarly, when the merger takes place in the first stage, the expected profits of the merged firm $E(\pi_M)$ and of the outsiders $E(\pi_O)$ can also be split into two parts.

### 2.3.2 Merger incentives

Since firms are ex-ante symmetric and the profits of the merged entity are shared equally between the $k$ insiders, $E(\pi_I) = \frac{E(\pi_M)}{k}$, there is no conflict of interest regarding the desirability of a merger. Each firm finds it profitable whenever $\Delta E(\pi_I) = E(\pi_I) - E(\pi_N) \geq 0$.

**Lemma 2.1.** *The expected gains of a merger can be split into two parts* $\Delta E(\pi_I) \equiv \Delta g_I^D + \Delta g_I^U$*, where* $\Delta g_I = g_I - g_N$*.*

Using the decomposition of the expected profits (see (2.6) and (2.7)), merger incentives within uncertain markets can be studied in two steps. Firstly, the term $\Delta g_I^D$ measures the change that would arise in the equivalent deterministic market, where $\theta_j = \overline{\theta}$ for $j = 1, \ldots, n$ with probability one. This expression is identical to the one derived by Perry and Porter (1985). Secondly, the term $\Delta g_I^U$ measures the change in profits derived from the *introduction* of the uncertainty. The results are stated in the following two propositions.

**Proposition 2.2.** *In the equivalent deterministic market (where* $\theta_j = \overline{\theta}$ *for* $j = 1, \ldots, n$*), mergers are profitable only if the market is very concentrated.*

The incentives for $k$ firms to merge in a deterministic environment depend on a trade-off. Even though merging firms' production is lower ($r_I^D < r_N^D$) the market price is higher. Indeed, although the outsiders increase production ($r_O^D > r_N^D$), they do not compensate for the decrease by insiders ($kr_I^D + (n-k)r_O^D < nr_N^D$). When the industry is very concentrated ($n$ very small) the decrease in joint production is compensated by the increase in price. In particular, a merger to monopoly (i.e. $n = k$) is always profitable (for any $\lambda$ and $k$). When the industry is less concentrated, the merging firms have less influence on price, and the reduction-in-production effect dominates.[19]

**Proposition 2.3.** *Under uncertainty and private information, firms have more incentives to merge than in deterministic markets.*

The revelation of information affects production decisions. If one insider receives a bad signal, the other insiders increase their production, shifting the first insider's residual demand curve down. Thus, the insider reduces its production still further. Likewise, if an insider receives a good outcome, it expands output even more. Thus, merging firms react more aggressively to the realization of uncertainty ($r_I^{U,O} > r_N^U$) and yet their output is less correlated with total output ($r_I^{U,O} + (k-1)r_I^{U,P} < r_N^U$). Thus, the first two terms in (2.7) increase following the merger whereas the third decreases (output rationalization also increases production volatility). However, the last term is dominated and the expected profits derived from uncertainty increase.

The previous two propositions lead to the following corollary, stated in terms of the importance of the uncertain ($\sigma_\theta^2$) with respect to the deterministic parts ($a - \overline{\theta}$).

**Corollary 2.4.** *In the basic model under private information,*

*(a) When uncertainty is low with respect to demand, mergers are profitable only if the market is very concentrated.*

*(b) When uncertainty is high with respect to demand, mergers are always profitable.*

*(c) For intermediate levels of uncertainty, mergers are profitable when the market is concentrated or very unconcentrated.*

For low values of $n$, the deterministic and uncertain parts move in the same direction and hence mergers are profitable. For higher values, the deterministic part produces losses (Proposition 2.2) whereas the uncertain generates gains (Proposition 2.3). When uncertainty is high these gains compensate any loss of the deterministic part. For intermediate levels of uncertainty, the gains compensate only when these losses are small. These results are illustrated in Figure 3.

[Insert Figure 3 about here]

[19] Even though our discussion is centered in the effects of the number of firms, comparative statics also show that firms have more incentives to merge as $\lambda$ increases.

The effects of mergers on non-participating firms are stated in the following proposition.

**Proposition 2.5.** *Outsiders always benefit from mergers.*

Although the expected production of outsiders increases, expected total production decreases when mergers take place. Therefore, in the equivalent deterministic market, outsider profits rise. This, coupled with the fact that expected profits derived from uncertainty do not change, implies that mergers within uncertain markets are always positive for non-participating firms.

### 2.3.3 Stability

When three or more firms are considering the possibility of merging ($k \geq 3$), the following interesting question might also be posed: provided that firms have incentives to merge, do they have incentives to break the agreement leaving the remaining insiders together? Define a stable merger as an agreement in which no firm has incentives to break away and become an outsider provided that if it left the other insiders would stay together. According to this definition, mergers in deterministic markets are in general not stable, given that it is non-participating firms which benefit most from the mergers (free-riding effect).

Similarly, in uncertain markets where firms have private information about a common demand parameter, Gal-Or (1988) shows that a merger generates an informational advantage to each outsider firm that exceeds the informational advantage of each insider. Thus mergers are even less stable than their deterministic counterparts. In our setting, when firms have private information about (independent) cost intercepts, the opposite result holds.

**Corollary 2.6.** *Mergers under uncertainty and private information are more stable than their deterministic counterparts.*

This corollary follows straightforwardly from the two propositions above. The uncertainty generates extra-profits for the merging firms (Proposition 2.3) but not for outsiders (Proposition 2.5). Therefore, a bigger share of industry profits is earned by the insiders, alleviating the free-riding effect.

### 2.3.4 Welfare consequences

Social welfare is represented by

$$W = \int_0^X D(z)\mathrm{d}z - \sum_{j=1}^{n} C(x_j).$$

Income effects are ignored and the standard welfare measure of consumer plus producer surplus is employed. In our case, with linear demand and linear marginal costs, social welfare can be written as

$$W = (a - \frac{X}{2})X - \sum_{j=1}^{n}(\theta_j + \frac{\lambda}{2}x_j)x_j.$$

Taking expectations, we can also rewrite expected welfare in terms of deterministic and uncertain parts, $E(W) \equiv w^D + w^U$, where

$$w^D = (a - \frac{\overline{X}}{2})\overline{X} - \sum_{j=1}^{n}(\overline{\theta} + \frac{\lambda}{2}\overline{x}_j)\overline{x}_j, \tag{2.8}$$

and

$$w^U = -\sum_{j=1}^{n} E[(x_j - \overline{x}_j)\,(\theta_j - \overline{\theta})] - \frac{1}{2}E[(X - \overline{X})^2] - \frac{\lambda}{2}\sum_{j=1}^{n} E[(x_j - \overline{x}_j)^2]. \tag{2.9}$$

$w^D$ represents the expected welfare that would arise in the equivalent deterministic market. The first term in $w^U$ represents the extra benefits arising from a more efficient distribution of output across firms (or plants). If one firm increases its responsiveness to the shock, not only are that firm's profits increased, but also total welfare is enhanced. The second term is the variance of aggregate output. Variability of output, *ceteris paribus*, reduces expected welfare. Although it increases consumer welfare (consumers receive lower prices when they consume more), it reduces industry profits by more. The last term, the sum of the variance of the output of each plant, reduces the expected profits of firms and expected social welfare.

Substituting the output decisions of Section 2.3.1 into (2.8) and (2.9), we obtain the expected welfare when the merger has occurred and when it has not. We can state the following two propositions.

**Proposition 2.7.** *In the equivalent deterministic market, mergers always reduce social welfare.*

In the absence of uncertainty, although mergers generate always more profits for outsiders and sometimes for insiders, they sharply reduce total production. As a consequence, consumer welfare is so far reduced that social welfare is lower.

**Proposition 2.8.** *Under uncertainty and private information, mergers are less harmful for social welfare.*

To understand this proposition let us refer to (2.9). Following the merger, the first term increases because total output is produced in a more cost efficient way. As explained in Section 2.3.2, merging firms react more aggressively to the cost realization and therefore low-cost plants produce relatively more than high-cost ones. In addition, non-participating firms do not change their reaction. This leads us to the second effect. The second term in (2.9) increases because total production volatility is reduced. This is due to the fact that a merged firm has less variability in output than independent firms. The third term, in contrast, decreases after the merger because the production volatility of each plant increases. Summing up, the last term is always dominated by the first two and hence social welfare increases.

The two propositions above form the basis of the welfare trade-off. On the one hand mergers increase market power and decrease social welfare. On the other hand, mergers aggregate information and increase welfare. Two cases may arise:

**Corollary 2.9.** *In the basic model under private information,*

*(a) When uncertainty is low with respect to demand, mergers always reduce social welfare.*

*(b) When uncertainty is higher, mergers increase social welfare if the market is not concentrated.*

If uncertainty is low with respect to demand the market power loss dominates and therefore when $k$ firms merge expected welfare is always reduced. If uncertainty is higher, the aggregation information gain dominates when the market power loss is small, i.e. when $n$ is high. These results are illustrated in Figure 4.

[Insert Figure 4 about here]

## 2.4 Uncertainty and public information

In the foregoing section we show that the introduction of random private shocks increases the incentives to merge and lessens the impact of mergers on social welfare. These results are driven by the aggregation of information following the merger and the subsequent rationalization of output between merging firms.

This section and the following isolate these two effects in turn. In this section we assume that firms receive public shocks rather than private ones. Here, there is rationalization of production but no information aggregation since all the information is public. In the next section firms may form informational coalitions instead of mergers. A group of firms may commit to share their private information but will then compete in the product market. There is information aggregation but no rationalization of output.

### 2.4.1 Merger incentives

As in Section 2.3, a group of firms are considering the possibility to merge in an uncertain market. In this case each firm receives perfect information about the parameters of all the firms in the market.

Under uncertainty and public information firms do not always have more incentives to merge than in the equivalent deterministic market. Consider for example a $n$-firm market where two may merge ($k = 2$) and $\lambda = 5$. If this market has more than 17 firms ($n > 17$), the introduction of public random shocks would reduce the incentives to merge. Thus, the introduction of a (highly volatile) random shock may make a previously profitable merger unprofitable.

**Remark 2.10.** *Under uncertainty and public information, firms may have less incentives to merge than in deterministic markets.*

As in the private information case, the merging firms rationalize output. Each plant reacts more aggressively to its own shock and the total firm output is less correlated with total output even if the volatility of each plant increases. However, when there is no informational advantage, the first two effects are weaker and do not always offset the third. The rationalization of production alone does not necessarily provide more incentives to merge.

Furthermore, even when the introduction of random public shocks increases the incentives to merge, those incentives are lower than if the shocks were private.

**Proposition 2.11.** *Firms have always more incentives to merge under private than under public information.*

Therefore we should observe many more mergers in uncertain markets when the realization of the uncertainty is private rather than public, *ceteris paribus*.

### 2.4.2 Welfare consequences

The implications for social welfare run parallel to those obtained for merger incentives.

Under uncertainty and public information mergers are not necessarily socially less harmful than in deterministic markets. Take for example a $n$-firm industry where two ($k = 2$) may merge and $\lambda = 5$. If this market has more than two firms ($n > 2$), mergers are even less desirable. Greater volatility makes the consequences of mergers even worse.[20]

**Remark 2.12.** *Under uncertainty and public information, mergers may be even worse than in deterministic markets.*

As mentioned above, here the rationalization of output is less strong. Although total output is produced in a more cost-efficient way, its total variance may increase. Mergers may be even less desirable than in deterministic markets.

**Proposition 2.13.** *Mergers are always better for social welfare under private than under public information.*

Although mergers in uncertain environments may be better regardless of the information type, they are always more desirable when there is private information.

## 2.5 Informational coalitions

The framework of this paper allows comparison between mergers and alliances to share information, an intermediate form of association. Modifying the basic model

[20] Note that when the uncertainty is very high and $2 < n \leq 17$, firms have incentives to merge but mergers would imply social losses.

under private information, $k$ firms envisage forming a coalition that will exchange their private information but not coordinate their actions in the product market.

Shapiro (1986) shows that firms always have incentives to form an informational coalition. The proposition below states the cases in which, if they could choose, firms would prefer to merge rather to form informational coalitions.

**Proposition 2.14.** *(a) When uncertainty is low with respect to demand, firms will prefer to merge rather than form an informational coalition only if the market is very concentrated.*

*(b) When uncertainty is high with respect to demand, they will always prefer to merge.*

*(c) For intermediate levels of uncertainty, they will prefer to merge when the market is concentrated or when it is very unconcentrated.*

With respect to the deterministic part, the comparison between a merger and an informational coalition is the same as when studying the incentives to merge. In the absence of uncertainty, informational coalitions have no value. The profits derived from uncertainty are always larger when firms merge. If they form a coalition, they do not get the full benefits of cutting their production in the event of a bad signal. Their rationalization is less strong and hence their expected profits lower.

However, Shapiro (1986) shows that when a group of firms share their private cost information, social welfare increases. Surprisingly, the informational part is not always better when a merger is formed. Even if the merging firms are better-off with a merger, the consumers will prefer an informational coalition because the output variance is higher. In some cases, an informational coalition will be socially preferred.

**Remark 2.15.** *The welfare derived from uncertainty may be greater when firms form an informational coalition instead of a merger.*

Therefore, even when uncertainty is high an informational coalition may be socially preferred to a merger.

## 2.6 Uncertainty and private information: a generalized information structure

This section generalizes the information structure of the basic model.[21] The generalization is two-fold. Firstly, the random marginal cost intercepts (or the idiosyncratic random demand intercepts) may be correlated. Secondly, the firms receive private signals about their parameters that may be noisy.

The joint distribution of the random variables has to be restricted. The information structure should yield affine conditional expectations. In that case, the linear-quadratic model has a unique (and affine in information) Bayesian Nash equilibrium. In what follows the random variables are assumed for the sake of convenience to be jointly normally distributed.[22]

Before uncertainty is realized, all firms face the same prospects. The vector of random variables $(\theta_1, \ldots, \theta_n)$ is jointly normally distributed with $E(\theta_j) = \overline{\theta}$, $Var(\theta_j) = \sigma_\theta^2$ and $Cov(\theta_j, \theta_l) = \rho\sigma_\theta^2$, for $j \neq l$, $0 \leq \rho \leq 1$. $\rho$ is the correlation coefficient between $\theta_j$ and $\theta_l$.[23]

Each firm receives a signal $s_j = \theta_j + \epsilon_j$, where $\epsilon_j \sim N(0, \sigma_\epsilon^2)$, $Cov(\epsilon_j, \epsilon_l) = 0$ for $j \neq l$ and $Cov(\theta_j, \epsilon_l) = 0$ for all $j$ and $l$. Signals can range from perfect ($\sigma_\epsilon^2 = 0$ or infinite precision) to pure noise ($\sigma_\epsilon^2 = \infty$ or zero precision). The precision of a signal $s_i$ is denoted by $\tau_\epsilon = \frac{1}{\sigma_\epsilon^2}$.[24]

Under the normality assumption, conditional expectations are affine. Each single-plant firm receives a signal $(s_j)$ and needs to estimate its own realization $(\theta_j)$ and the signals of the other firms $(s_w)$. We have $E(\theta_j - \overline{\theta}|s_j) = t(s_j - \overline{\theta})$ and $E(s_w - \overline{\theta}|s_j) = E(\theta_w - \overline{\theta}|s_j) = \rho t(s_j - \overline{\theta})$, where $t = \frac{\tau_\epsilon}{\tau_\theta + \tau_\epsilon}$. Note that $0 \leq t \leq 1$. In particular when signals are perfect: $t = 1$, $E(\theta_j - \overline{\theta}|s_j) = (s_j - \overline{\theta})$ and $E(s_w - \overline{\theta}|s_j) = \rho(s_j - \overline{\theta})$. When they are uninformative: $t = 0$, $E(\theta_j - \overline{\theta}|s_j) = E(s_w - \overline{\theta}|s_j) = 0$.

The $k$-plant firm receives $k$ signals $(s_1, \ldots, s_k)$ and needs to estimate the realiza-

[21] See Section 8.1 in Vives (1999).

[22] There are other pairs of prior distribution and likelihood that result in affine conditional expectations and do not require unbounded support for the uncertainty (see Vives, 1988). Normal distributions, however, make the analysis simpler.

[23] $\rho$ is assumed to be positive because it is the natural case in practice.

[24] Similarly, the inverse of $\sigma_\theta^2$ is denoted by $\tau_\theta$.

tion of each of its plants

$$E(\theta_i - \overline{\theta}|s_1, \ldots, s_k) = \frac{t[1 - \rho t + \rho t(k-1)(1-\rho)]}{(1-\rho t)[1 + \rho t(k-1)]}(s_i - \overline{\theta}) + \frac{\rho t(1-t)}{(1-\rho t)[1+\rho t(k-1)]}\Sigma_{p=1, p\neq i}^{k}(s_p - \overline{\theta}),$$

and the signal of outsiders

$$E(s_o - \overline{\theta}|s_1, \ldots, s_k) = \frac{\rho t}{1 + \rho t(k-1)}\Sigma_{i=1}^{k}(s_i - \overline{\theta}).$$

The following two lemmas characterize the equilibria when a merger has occurred and when has not.

**Lemma 2.16.** *When no merger has occurred, the strategies followed by each firm are given by* $x_j(s_j) = r_N^D(a - \overline{\theta}) - r_N^U(s_j - \overline{\theta})$ *for* $j = 1, \ldots, n$, *where* $r_N^D$ *is defined in (2.3) and*

$$r_N^U = \frac{t}{2 + \lambda + \rho t(n-1)}. \tag{2.10}$$

In contrast to the basic model, the market structure affects the responsiveness when the parameters are positively correlated. Intuitively, when one firm receives a good signal, it is likely that the other firms have also received good ones. In consequence the reaction is less strong as the number of firms increases since more rivals are likely to push up production. The reaction is also less strong when the signals are more correlated or less precise.

**Lemma 2.17.** *When a merger takes place, the aggregated production of the merged firm is* $x_M(s_1, \ldots, s_k) = kr_I^D(a - \overline{\theta}) - r_M^U\Sigma_{i=1}^{k}(s_i - \overline{\theta})$, *where* $r_I^D$ *is defined in (2.4) and*

$$r_M^U = \frac{t[(2 + \lambda - \rho t)[1 + \rho(k-1)] - (n-k)\rho t(1-\rho)(k-1)]}{V(n,k,\rho,t)}, \tag{2.11}$$

*meanwhile, the outsiders will produce* $x_o(s_o) = r_O^D(a - \overline{\theta}) - r_O^U(s_o - \overline{\theta})$ *for* $o = k + 1, \ldots, n$, *where* $r_O^D$ *is defined in (2.5) and*

$$r_O^U = \frac{t[(2k + \lambda)[1 + \rho t(k-1)] - \rho tk[1 + \rho(k-1)]]}{V(n,k,\rho,t)}, \tag{2.12}$$

*where*

$$V(n,k,\rho,t) = (2k+\lambda)[1+\rho t(k-1)](2+\lambda-\rho t) + (n-k)\rho t[(2k+\lambda)[1+\rho t(k-1)] - \rho t k^2].$$

This information structure encompasses the three cases analyzed by the information sharing literature: independent values, private values and common value. The independent values model is analyzed in the foregoing sections. Firms receive perfect signals ($t = 1$) and the random parameters are independent ($\rho = 0$). In the following subsections the latter two models are studied. In the private values model, firms also receive perfect signals ($t = 1$) but the random parameters are not independent ($0 < \rho < 1$). In the common value model, firms receive noisy signals ($t < 1$) of the same random parameter, or equivalently, of different parameters that are perfectly correlated ($\rho = 1$).

### 2.6.1 Private values model

In the private values model, firms receive perfect signals ($t = 1$) but the random parameters are not independent ($0 < \rho < 1$). This can be applied to an industry in which firms can partially infer the costs (or demands) of other firms once they know their own costs (or demands).[25]

When the parameters are correlated firms may have less incentives to merge than in deterministic environments. Take for example a four-firm industry ($n = 4$) where two decide whether to merge ($k = 2$) and $\lambda = 1$. These firms have more incentives to merge than in deterministic markets only if $\rho < 0.985$.[26] For larger values, they have less incentives to merge.

**Remark 2.18.** *In the private values model,*

*(a) When the correlation of the parameters is weak, firms have more incentives to merge than in deterministic markets.*

*(b) When the correlation is strong, firms may have less incentives to merge.*

[25] Suppose for example that firms have a raw material in common. By observing its cost, each firm can guess the costs of its rivals.

[26] Note that when $\rho \to 0$ the results tend to those obtained in the independent values model. Firms should always have more incentives to merge when $\rho \to 0$.

When the parameters are correlated, the expected profits due to a more efficient distribution of the production among the insiders not only depend on the reaction to one's own parameter, but also on the reaction to the signals of the other insiders.

$$-E[(x_i - \overline{x}_i)(\theta_i - \overline{\theta})] = \left[r_I^{U,O} - \rho(k-1)r_I^{U,P}\right]\sigma_\theta^2.$$

Intuitively, a positive signal for one given insider is likely to be related to positive signals for the other insiders. Responsiveness to one's own signal is likely to be restrained by the reaction to the signals of the others. As $\rho$ increases, insiders receive similar signals more often. For very large values of $\rho$, the correlation between production and signal is higher (and the second term in (2.7) lower) after the merger ($r_I^{U,O} - (k-1)r_I^{U,P} = r_M^U < r_N^U$). Hence, the expected profits derived from the uncertainty may be greater when firms remain independent.

### 2.6.2 Common value model

In the common value model, firms receive noisy signals ($t < 1$) of the same random parameter, or equivalently, of different parameters that are perfectly correlated ($\rho = 1$). This can be applied to an industry in which equally efficient firms receive some imperfect (and private) information about the uncertain market demand.

As in the previous subsection, firms do not always have more incentives to merge under uncertainty. Take again a four-firm industry ($n = 4$) where two may merge ($k = 2$) and $\lambda = 1$. These firms have more incentives to merge only if $t < 0.8$. For larger values, they have less incentives to merge than in deterministic environments.

**Remark 2.19.** *In the common value model,*

*(a) When signals are not very precise, firms have more incentives to merge than in deterministic markets.*

*(b) When signals are very precise, firms may have less incentives to merge.*

In the independent and private values models the important feature is the reaction to each parameter. The merged firm receives perfect signals about different parameters and produces different quantities in each plant. In contrast, in the common value setup, each merging firm produces the same amount ($r_I^U = \frac{r_M^U}{k}$). Here, the importance hinges upon the accuracy of the prediction and upon responsiveness to that prediction. The merged firm collects several signals and thus has a more accurate prediction than single plant firms. Specifically, denoting $\theta \equiv \theta_j$ $(j = 1, \ldots, n)$,

$$Var(\theta|s_1, \ldots, s_k) = \frac{1-t}{1+t(k-1)}\,\sigma_\theta^2 < (1-t)\,\sigma_\theta^2 = Var(\theta|s_j).$$

Concerning production decisions, however, insiders may be less aggressive than outsiders ($r_I^U < r_O^U$). This happens when $t \geq t^* = \frac{\lambda}{k+\lambda}$. In particular, as shown by Gal-Or (1988), when $\lambda = 0$ insiders are always less responsive than outsiders.[27] The reason relates to the implication of collusion on the Cournot behaviour of oligopolistic firms. Collusion between equally efficient firms means reduced production by each in order to accommodate the others. When $\lambda$ increases, the accommodation effect is alleviated: if the signals are not very precise ($t < t^*$), the merged firm responds more aggressively because it has a better prediction than the single plant firms.

When signals are not very precise ($t$ low), insiders respond more aggressively and predict much better following the merger. Hence firms have more incentives to merge. In contrast, when signals are very precise ($t$ large), insiders are less aggressive and their accuracy hardly increases at all. Hence, the merger may even generate an informational disadvantage to the merging firms.

Note however that the above observation leaves unanswered whether, under common values, we will observe more or less mergers than in deterministic environments. It may be that the informational disadvantage arises *only* when firms already have no incentive to merge in the deterministic framework and hence more mergers should be observed. The following proposition, restricted to the case $\lambda = 0$, shows that this is in fact the case.

**Proposition 2.20.** *When firms sell homogeneous goods and marginal costs are constant ($\lambda = 0$), more mergers take place in the common value model than in the equivalent deterministic market.*

Thus, complementing the work of Gal-Or (1988), even if the merger generates an informational disadvantage to the merging firms, this informational disadvantage

[27] In the common value model, the positive production assumption does not imply $\lambda > 0$. If $\lambda = 0$ the merged firm is indifferent between closing some plants or keeping all of them producing. Assuming that the latter happens, the results of this section for the particular case $\lambda = 0$ are equivalent to those obtained by Gal-Or (1988).

never discourages a merger. On the contrary, the informational advantage may arise in cases where the firms have no incentives to merge in deterministic markets and therefore may encourage mergers.

## 2.7 Concluding remarks

Motivated mainly by the needs of competition authorities, a large strand of literature studies the positive and normative aspects of horizontal mergers. However, this literature generally assumes that firms have perfect knowledge about the market conditions at the instance of taking merger decisions. In practice, this is rarely the case. In this paper, we analyze the effects of uncertainty and private information on horizontal mergers.

Common wisdom suggests that more uncertain markets are related to more incentives to merge. We show formally that this is not always the case. When the uncertainty is publicly observed, firms may have less incentives to merge than in deterministic markets. Indeed, uncertainty *per se* does not lead to more concentrated industries and may even discourage mergers that would have been profitable. In contrast, when the uncertainty is privately observed, firms always have more incentives to merge and more uncertainty results in more concentrated industries.

The private information results are firstly derived for the case in which firms receive perfect signals about their uncertain and independent characteristics. We show afterwards that firms also have more incentives to merge when the characteristics are mutually related and when the signals are not perfect. However, when the signals are precise and the characteristics very correlated, firms may have less incentives to merge than in deterministic markets. Indeed, in this case they can infer all the information about their rivals and we are close to the situation in which public information is received. Thus, mergers in uncertain markets are more profitable as long as firms retain some degree of private information.

The consequences of mergers on social welfare in uncertain markets also depend on the type of information. When the uncertainty is publicly observed, mergers may be socially worse than in deterministic markets. In the presence of private information, mergers in uncertain markets not only take place more frequently but are also better for social welfare. We show that in this case the aggregation of disseminated information results in social gains.[28] In markets with high volatility, these gains can offset the anti-competitive effects of mergers and hence mergers under uncertainty and private information enhance welfare.

[28] In this sense, our paper provides a new argument for the so-called efficiency defense of mergers. Even if some OECD merger control systems already take into account the positive sides of mergers, e.g. in the United States, the role of efficiencies is still not considered in the European merger policy (Röller et al., 2001a).

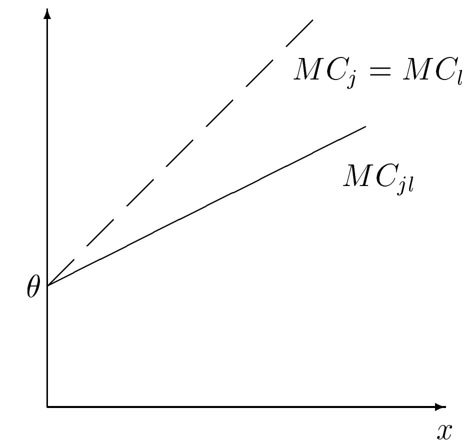


Figure 1: Marginal Costs of a two-plant merged firm and marginal costs of a big single-plant merged firm (identical merging firms).

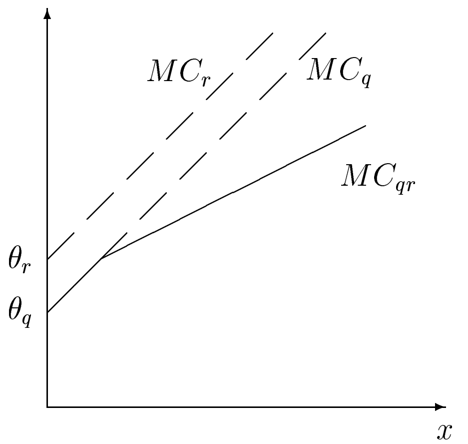


Figure 2: Marginal Costs of a two-plant merged firm and marginal costs of a big single-plant merged firm (different merging firms).

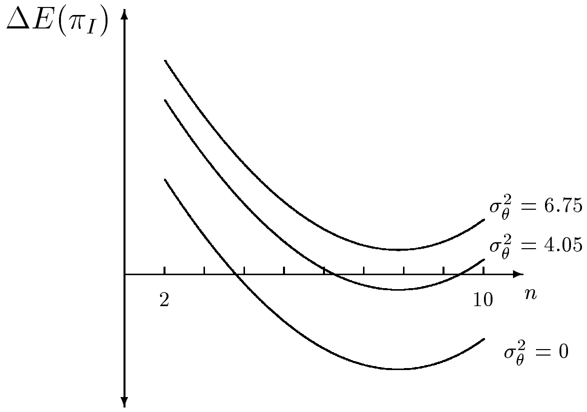


Figure 3: Merger incentives for different levels of uncertainty when $(a - \overline{\theta}) = 10$, $\lambda = 4$ and $k = 2$ taking into account the positive production assumption (see the Appendix A).

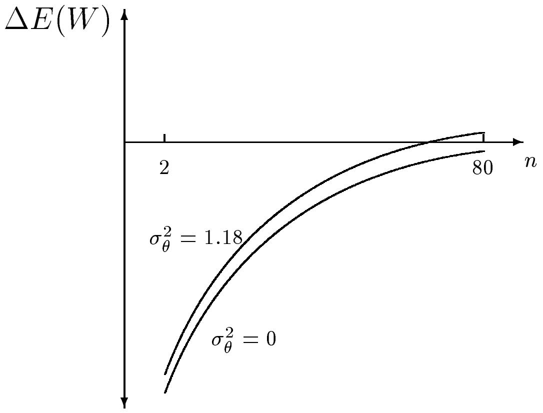


Figure 4: Consequences of mergers for social welfare in deterministic and uncertain markets when $(a - \overline{\theta}) = 10$, $\lambda = 8$ and $k = 2$ taking into account the positive production assumption (see the Appendix A).

## Chapter 3

# Mergers with Product Market Risk

(This is jointly written with Marco Ottaviani)

## 3.1 Introduction

Mergers allow firms to better share and diversify their risk, or at least this is the claim often made by the merging firms. As there are neither cost synergies nor demand interdependencies among firms operating in different sectors, diversification is indeed one of most prominent motives for conglomerate mergers.[1] This desire to diversify is compatible with the reluctance of many companies to take risk, as witnessed by the large amount of corporate hedging activity and the executive obsession with risk management.[2]

Risk sharing is also cited as a reason for merging by firms operating in interdependent markets. For example, package tour operators sign contracts with airlines and hoteliers well before knowing the realization of demand. If demand at a particular location falls short of the expectations due to unforeseen events (such as unrest in the area or change in consumers' taste), the operators are unable to sell all their capacity

[1]It is a hotly debated issue whether shareholders need at all this diversification. With perfect capital markets diversification through mergers is of no value to shareholders, who should already hold perfectly diversified portfolios (Levy and Sarnat (1970)). But, as discussed in Section 3.5, in reality many firms are either controlled by undiversified large shareholders or run by risk averse managers. See Amihud and Lev (1981) for an empirical investigation of the managerial risk reduction motive of conglomerate mergers.

[2]See our discussion in Section 3.5 and references cited therein.

or sell it at heavily discounted prices. They should then be cautious when setting the production capacity to avoid the risk of large losses, experienced at great grief in some years.[3] Could competition be more effective after a merger? Under which conditions are mergers more likely to take place because of diversification? Can consumers benefit and social welfare increase as a result of these mergers?

To address these questions, we consider risk averse firms competing in the presence of uncertainty.[4] Risk averse firm behavior can originate from the presence of non-diversified owners, liquidity constraints, delegation of control to risk-averse managers, or stochastic production. As as discussed in detail in Section 3.5, in these circumstances the amount of hedging is often limited by transaction costs and the presence of moral hazard.

In the monopoly case, the effect of risk aversion depends on the type of uncertainty and the monopolist's choice variable (Baron (1971) and Leland (1972)). A *quantity setting* monopolist concerned about demand or cost risk, chooses a lower quantity in order to reduce the variability of profits. A *price setting* monopolist sets a higher price in the presence of cost uncertainty, but a lower price with demand uncertainty. In an oligopoly setting, risk averse firms enjoy softer competition (i.e., lower quantities or higher prices), except when they commit to prices before knowing the uncertain realization of demand (Asplund (2002)). We should then expect that, for example, tour operators set lower capacities the more risk averse they are.

[3] For more details on the importance of risk in package tour business, we refer to the discussion in the Airtours/First Choice decision by the EU Competition Commission (1999): "Information from the major tour operators confirms that operators' capacity plans, and the associated contracts with hoteliers and airlines, are typically fixed 12-18 months ahead of the holiday season". "Only by contracting for their expected needs well ahead of time, enabling suppliers to plan ahead, can operators obtain a sufficiently low price to attract an adequate volume of profitable sales." "The tour operator, accordingly, bears almost all of the risk of any contracted capacity remaining unsold." "Matching capacity and demand is therefore critical to profitability, especially since package holidays are perishable goods – a given package loses all its value unless it is sold before its departure date". "But suppliers of package holidays are severely hampered in precisely aligning capacity and demand. They need to 'produce' (i.e. contract for the necessary flights, accommodation etc) virtually the whole of what they expect to sell a long time before it is 'consumed' (i.e. when the consumer departs for the holiday destination, or at the earliest, when the consumer pays the bulk of the price – usually around 8 weeks before departure." "The large operators take a cautious approach to capacity planning, taking particular note of the estimates of the other major operators plans."

[4] As will be shown below, the amount of hedging is limited by the presence of moral hazard in insurance.

Our model features ex-ante symmetric firms with mean-variance preferences. Firms face a linear demand system with differentiated (substitutable or complementary) products and may compete either in quantities or prices, whereas the uncertainty may be about either the intercept of the firms' demand or the level of marginal costs.[5] Before the competition stage, we allow a number of firms to merge, as in the exogenous merger model of Salant et al. (1983). This is the simplest model for studying the market conditions under which risk aversion can make mergers privately profitable and socially desirable, so that risk sharing can be a valid "efficiency defence".

In the presence of risk aversion, a novel distinction emerges between types of mergers depending on how the claims to uncertain profits are split. In a complete acquisition (or "*takeover*"), the acquiring firm bears alone all the uncertainty of the new entity. In a proper merger (or "*merger of equals*"), this risk is evenly split among the constituent firms. More generally, the higher the fraction of payments made in cash relative to shares of the new entity, the more risk the acquiring owners have to face when in control. The contractual split of profits has then two effects. First, it directly affects the payoff of the acquiring firm, and in turn the amount the firm can pay to the acquired firms and thus the viability of the transaction. Second, by determining the risk bearing attitude of the controlling stakeholder, it affects the strategic behavior in the product market and thus the level of ex-post expected profits.[6] Merging firms determine the optimal contractual split of profits by taking into account both the diversification and the strategic effects.

To illustrate our results, consider first a merger of a group of ex-ante symmetric firms competing in quantities, as in the package tours operators example. In this case, the best consolidation agreement is a merger of equals. By holding equal shares in the merged firm, the constituent firms achieve the best possible risk diversification and commit to the most aggressive behavior in the product market. Responding to a tougher competitor, the rivals will cut production, leaving a higher market share and thus more profits for the merged firm. While in the absence of risk aversion, total

[5]Our setup is similar to the one considered by Brown and Chiang (2002) for the case of Cournot competition. While their focus is on endogenous coalition formation, we are interested in comparing private with social incentives to merge.

[6]The sharing rule can be seen as a *credible* device to commit to certain strategic behaviour in the product market. Notice the similarity with strategic delegation of decision making to managers (Fershtman and Judd (1987)).

production by the merging firms always decreases as a result of the merger, with risk aversion production tends to decrease by less or can even increase. The number of mergers that are profitable increases with the level of risk aversion. If the firms are enough risk averse, competition becomes so much tougher as a result of the merger that consumers and society are made better off.

Price competing firms would not always agree to merge as equals. With cost uncertainty, firms face a trade off between diversification and strategic commitment. They can diversify by merging as equals but they induce the softest behavior in a takeover. Forced to choose a sharing rule between merger and takeover, merging firms may be induced to set lower prices while keeping the merger profitable. Outsiders would indeed cut their prices and consumer and social welfare may increase following the merger. With demand uncertainty, diversification results instead in softer behavior, so that mergers are clearly profitable but reduce consumer surplus.

The paper proceeds as follows. The model is introduced in Section 3.2. Section 3.3 derives the results of Cournot competition and Section 3.4 those of Bertrand. Section 3.5 discusses rationales for risk aversion and Section 3.6 concludes. Proofs are in the Appendix.

## 3.2 Model

We introduce the possibility of mergers in an oligopolistic industry with $n$ risk averse firms, each producing a differentiated product. The game unfolds in three stages. First, merger decisions take place. Second, the existing firms compete in the product market, either in quantities or in prices, facing either demand or cost uncertainty. Third, the uncertainty is realized and consumers make their purchasing decisions.

*In the first stage*, a group of $k$ firms (including the first $k$ firms, $t = 1, ..., k$) decide whether to merge, joining their production possibilities into a single firm. At this point, the owners of the merging firms (or "insiders") set the conditions of the agreement, by determining the allocation of fixed cash payments ($F_t$) and shares of the profits of the new entity ($\tau_t$). We do not allow negative shares and require that the scheme is balanced, so that $\tau_t \geq 0$, $\Sigma_{t=1}^{k} \tau_t = 1$ and $\Sigma_{t=1}^{k} F_t = 0$. For simplicity, we assume that decision making is then delegated to the new company's largest shareholder, $l = \arg\max_{t \in \{1,...,k\}} \tau_t$[7]. Firm $l$ will effectively run the merged company by taking the output or price decisions related to all the insiders' products. The payoff structure (fixed fee and percentage of joint profits) affects the strategic behavior in the product market competition, the next stage of the game.

*In the second stage*, the existing firms compete in either quantities or prices and face either demand or cost uncertainty. Each firm is assumed to have identical mean variance preferences, represented by the utility function $U(\Pi^i) = E(\Pi^i) - \frac{R}{2}Var(\Pi^i)$, where $\Pi^i$ are firm $i$'s random profits and $R$ the coefficient of risk aversion common to all firms.[8] In the case of *demand uncertainty*, we assume that firms produce with constant marginal costs, normalized to 0 for simplicity, and that they face demands characterized by the random parameters $\theta_i$, identically distributed with mean 0, variance $\sigma^2$ and $Cov(\theta_i, \theta_j) = \rho\sigma^2$ for $i \neq j$.[9] In the case of *cost uncertainty*, we assume instead that demand is constant ($\theta_i \equiv 0$) and that firms have random and constant marginal costs $\upsilon_i$ with the same distribution as the above-specified uncertain demand parameters.

*In the third stage,* once the uncertainty has been realized, consumers make their choices. We assume that the representative consumer has preferences over the $n$ goods given by the utility function

$$V(x_1, ..., x_n) = \sum_{i=1}^{n}(a - \theta_i)x_i - \frac{1}{2}(\sum_{i=1}^{n} bx_i^2 + \sum_{j \neq i} dx_i x_j),$$

where $b > 0$, $b > d$, $a - \theta_i > 0$ and $b + (n-1)d > 0$.[10] The goods are substitutes, independent, or complements depending on whether $d \gtreqless 0$. The goods are perfect substitutes when $b = d$. Solution of the consumer's maximization problem gives rise to the linear inverse demand system

$$p_i = a - \theta_i - bx_i - dX_{-i}.$$

[7]Notice that $\tau_l \in [1/k, 1]$.

[8]Mean-variance preferences can be obtained through a constant absolute risk aversion (CARA) utility function with normal random shocks. We disregard problems arising from negative values.

[9]The shocks are positively, independently or negatively correlated depending on whether $\rho \gtreqless 0$. From $Var(\sum_{i=1}^{n} \theta_i) = Cov(\sum_{i=1}^{n} \theta_i, \sum_{i=1}^{n} \theta_i) = \sigma^2 n(1 + \rho(n-1)) \geq 0$ we have the constraint $\rho \geq -\frac{1}{n-1}$.

[10]These assumptions ensure that $V$ is strictly concave.

Direct demands functions are

$$x_i = \alpha - \mu_i - \beta p_i + \gamma p_{-i},$$

where $\alpha = \frac{a}{b+(n-1)d}$, $\mu_i = \frac{\theta_i}{b+(n-1)d}$, $\beta = \frac{b+(n-2)d}{(b+(n-1)d)(b-d)}$, $\gamma = \frac{d}{(b+(n-1)d)(b-d)}$ and therefore $\beta + \gamma > 0$ and $\beta - (n-1)\gamma > 0$. Again, just for the clarity of the exposition, we denote the distribution of $\mu_i$ as those of the other random parameters. In part of the analysis, we will focus on the special cases with homogeneous goods ($b = d$) and independent shocks ($\rho = 0$).

We now proceed to the analysis of the subgame perfect Nash equilibrium of this exogenous merger game, treating the number $k$ of merging firms as a parameter of the model.

## 3.3 Cournot Competition

We start by considering quantity (Cournot) competition. In this case, the analysis for either demand or cost uncertainty is identical. For example, the profits of an independent firm are

$$\Pi^i_{q,d} = (a - \theta_i - bx_i - dX_{-i})x_i,$$

with demand uncertainty and

$$\Pi^i_{q,c} = (a - bx_i - dX_{-i})x_i - \upsilon_i x_i,$$

with cost uncertainty. From $E(\Pi^i_{q,d}) = E(\Pi^i_{q,c})$ and $Var(\Pi^i_{q,d}) = Var(\Pi^i_{q,c})$, we have $U(\Pi^i_{q,d}) = U(\Pi^i_{q,c})$.[11] This section's analysis then applies to both demand and cost uncertainty.

### 3.3.1 Production

In the benchmark case in which no merger has taken place in the first stage, each firm in the second stage solves

$$Max_{x_i}(a - bx_i - dX_{-i})x_i - \frac{R}{2}\sigma^2 x_i^2. \tag{3.1}$$

[11] If we had not denoted cost and demand distributions equally, we would not have the same utility but an equivalent one.

In the unique equilibrium production is then identical for all firms $i = 1, ...n$, with

$$x_i \equiv x = \frac{a}{2b + d(n-1) + R\sigma^2}. \tag{3.2}$$

As shown more generally by Asplund (2002), a higher level of risk aversion relaxes competition, resulting in a reduction in the quantity produced by all firms.

Suppose that $k$ firms decide to merge. Denoting with $\tau \equiv \tau_l$ the share of profits of the largest shareholders of new entity and recalling the assumption that the largest shareholders controls all the insiders' production decisions, the merged entity objective function is

$$Max_{x_1,...,x_k} \sum_{t=1}^{k} (a - bx_t - dX_{-t})x_t - \frac{R}{2}\sigma^2\tau(\sum_{t=1}^{k} x_t^2 + \rho \sum_{t,j,t\neq j} x_t x_j).$$

The outsiders ($o = k+1, ..., n$) maximize (3.1) as before. Equilibrium outputs are

$$x_t = \frac{a(S-(n-k)d)}{SP - d^2(n-k)k} \text{ for } t = 1, ..., k \tag{3.3}$$

and

$$x_o = \frac{a(P-kd)}{SP - d^2(n-k)k} \text{ for } o = k+1, ..., n \tag{3.4}$$

where $S = 2b + (n-k-1)d + R\sigma^2$ and $P = 2b + (k-1)2d + \tau R\sigma^2(1 + \rho(k-1))$.[12] Note that a reduction in the stake of the largest shareholder effectively makes the merged firm less risk averse and therefore more aggressive. Merging firms' production is larger whereas, as a response, the outsiders' production is lower.

Comparing (3.2) and (3.3), the insiders increase their production after the merger whenever

$$(1 - \tau(1 + \rho(k-1)))R\sigma^2 \gtrless (k-1)d. \tag{3.5}$$

To interpret this condition, consider the case with substitute goods ($d > 0$). In the standard case without risk ($\sigma^2 = 0$) or risk aversion ($R = 0$), the insiders reduce production and so are better able exploit their increased market power. According to the right hand side of (3.5), the output reduction induced by the merger increases in the number of insiders and the substitutability of the goods. In the presence of

[12] Since $S-(n-k)d > 0$, $P-kd > 0$ and $SP-d^2(n-k)k > 0$ all firms produce a positive amount.

risk and risk aversion ($\sigma^2 R > 0$), a merger results in an increase in the risk bearing potential of the insiders, unless the shocks are perfectly positively correlated ($\rho = 1$). As the correlation in the shocks ($\rho$) decreases, it becomes more likely that a positive shock in one of the markets served by the merged entity is offset by a negative shock in one of its other markets. Because of this diversification effect, the merged entity is more willing to take risk by selling a higher output. Similarly, a reduction in the fraction of risk borne by the firm with decision power ($\tau$) increases risk bearing and so results in an increase in the insiders' output. When instead the goods are complements ($d < 0$), the insiders produce more as long as the level of risk averse-like behavior does not increase so much that it overcomes the strategic increase in production.

Comparing (3.3) and (3.4), the outsiders' shift in production is the opposite to the insiders' when the goods are substitutes and the same when they are complements,

$$d(1 - \tau(1 + \rho(k-1)))R\sigma^2 \leq (k-1)d^2. \tag{3.6}$$

However, their reaction never compensates the change of the insiders and the total production increases whenever condition (3.5) is satisfied.

Note that when firms are risk neutral, outsiders always increase production whereas the insiders' (and total) production is only increased when the goods are complements.

### 3.3.2 Optimal contract

We turn now to the determination of the optimal contract between the merging firms. Since the firms are identical, we assume that their owners should all receive the same expected utility level, $U^* \equiv U(\tau_i \Pi^* + F_i) = U(\tau_j \Pi^* + F_j)$ for all $i, j = 1, ..., k$, where $\Pi^*$ denotes ex-post profits of the merged firm. Imposing that $\Sigma \tau_t = 1$ and $\Sigma F_t = 0$, we then have

$$U^* = \frac{1}{k}[E(\Pi^*) - \Sigma \tau_t^2 \frac{R}{2} Var(\Pi^*)] \tag{3.7}$$

and

$$F_j = \frac{k\Sigma_{i \neq j}\tau_i - (k-1)}{k} E(\Pi^*) - \frac{\Sigma_{i \neq j}\tau_i^2 - (k-1)(1 - \Sigma_{i \neq j}\tau_i)^2}{k} \frac{R}{2} Var(\Pi^*) \tag{3.8}$$

for all $j$.

As the fixed payments must satisfy (3.8), the optimal contract is completely determined by the distribution of shares of the new company. It is worth considering in more detail two polar cases. First, the agreement is a *"takeover"* when one firm retains all the shares, that is $\tau_l = 1$, $\tau_j = 0$ for $j = 1, ..., k$, $j \neq l$ and hence $F_l = -\frac{k-1}{k}[E(\Pi^*) - \frac{R}{2}Var(\Pi^*)]$ and $F_j = \frac{1}{k}[E(\Pi^*) - \frac{R}{2}Var(\Pi^*)]$ for $j = 1, ..., k$, $j \neq l$ and $U^* \equiv \frac{1}{k}[E(\Pi^*) - \frac{R}{2}Var(\Pi^*)]$. Second, the agreement is a *"merger of equals"* when the shares are distributed equally, so that $\tau_t = \frac{1}{k}$ and $F_t = 0$ for $t = 1, ..., k$ and $U^* \equiv \frac{1}{k}[E(\Pi^*) - \frac{1}{k}\frac{R}{2}Var(\Pi^*)]$.

The contract affects the utility levels of the merging firms in two ways. Firstly, it determines the level of risk diversification implied by the merger. In a takeover, the risk is not diversified since the uncertain profits of the new firm are retained fully by the acquiring firm whereas the other firms obtain a fixed fee without any risk. Clearly, the optimal way to diversify any given amount of risk is to share the profits of the new firm equally. A merger of equals then maximize (3.7), holding $\Pi^*$ constant. But, secondly, the distribution of shares of the new company also affects the strategic incentives and in turn $\Pi^*$. Giving more shares to the largest shareholder results in a "less risk averse" merging firm. This in turn translates in a more or less aggressive behavior in the product market, depending on the type of uncertainty and the nature of competition.

**Proposition 3.1.** *Under Cournot competition, the optimal sharing rule is equal sharing ("merger of equals").*

In the case of Cournot competition, the two effects go in the same direction. An equal division of shares increases diversification and leads to a more aggressive behavior in the product market, for given strategies of the outsiders. In turn the outsiders reply to the insiders' increased quantity by reducing their quantity, shifting up the insiders' residual demand. As this indirect strategic effect is also to the advantage of the insiders, the insiders' total utility is maximized with an egalitarian division of the shares.

### 3.3.3 Private Incentives, Consumer and Social Welfare

In this section we study the incentives to merge and evaluate the consequences of a merger for consumers and for the entire society.

As showed by Salant et al. (1983), firms that produce homogeneous goods have rather limited incentives to merge when they are risk neutral. The merging firms become less aggressive after the merger since they internalize the competitive externality. In turn, the outsiders increase production, free-riding on the reduction of the insiders. Mergers then tend to be rather unprofitable. In the presence of risk aversion, however, the merged firm may become more aggressive following the merger due to diversification and increased risk bearing potential.

**Proposition 3.2.** *Under Cournot competition with homogeneous goods and independent shocks, more mergers take place for higher levels of risk aversion.*

Following Salant et al. (1983), Figure 1 depicts the incentives to merge when the firms are risk neutral and when they are risk averse.

[Insert Figure 1 about here]

When the goods are homogeneous, consumers are better off when more output is produced. From condition (3.5), a merger increases consumer welfare whenever $(1-\rho)R\sigma^2 \geqslant kd$. If the shocks are perfectly positively correlated, risk sharing has clearly no effect, so that mergers never increase consumer welfare. When the shocks are instead idiosyncratic, for high enough levels of risk aversion the merger reduces prices and benefits consumers.

For the non-merging firms there is never a conflict. Outsiders produce more than before the merger exactly when prices are higher. Therefore outsiders will be better off whenever condition (3.6) is satisfied, which, for substitutable goods, is equal to $(1-\rho)R\sigma^2 < kd$. Their profits are higher whenever the industry output and the consumer welfare is lower.

Summing up, the mergers not only take place more often in the presence of uncertainty and risk aversion but they are also better for society as a whole.

**Proposition 3.3.** *Under Cournot competition with homogeneous goods and independent shocks, when firms are risk neutral no merger increases social welfare. When they are risk averse, mergers may improve social welfare. As risk aversion or uncertainty increases, more mergers are welfare enhancing.*

Using the same example as before, we can plot the change in welfare due to a merger.

[Insert Figure 2 about here]

From Figures 1 and 2, we can see that small mergers, i.e. mergers involving a small part of the industry, are both profitable and welfare enhancing. Large mergers, however, even though they are privately profitable, they lower social welfare.

## 3.4 Bertrand competition

As opposed to the Cournot case, the utility of price competing firms depends on the type of uncertainty. The profits of an independent firm are with demand uncertainty

$$\Pi^i_{p,d} = (\alpha - \mu_i - \beta p_i + \gamma p_{-i})p_i$$

and with cost uncertainty

$$\Pi^i_{p,c} = (\alpha - \beta p_i + \gamma p_{-i})(p_i - \upsilon_i).$$

Notice that although $E(\Pi^i_{p,d}) = E(\Pi^i_{p,c})$ we have that $Var(\Pi^i_{p,d}) \neq Var(\Pi^i_{p,c})$ and hence $U(\Pi^i_{p,d}) \neq U(\Pi^i_{p,c})$. In the following subsections we study both cases in turn.

### 3.4.1 Bertrand competition with demand uncertainty

Bertrand competition with demand uncertainty and substitutable (complementary) products is the dual of Cournot competition with complementary (substitutable) products. We can obtain the utility function of one case from the other by identifying $q_i$ with $p_i$, $a$ with $\alpha$, $b$ with $\beta$, $c$ with $-\gamma$.[13] As a result, the equilibrium prices in this case can be easily obtained from the equilibrium quantities of Section 3.3. In turn, from conditions (3.5) and (3.6), the insiders price higher than before the merger whenever

$$(1 - \tau(1 + \rho(k-1)))R\sigma^2 \gtrless -(k-1)\gamma$$

and the outsiders whenever

$$\gamma(1 - \tau(1 + \rho(k-1)))R\sigma^2 \geq -(k-1)\gamma^2.$$

In this case, giving less stakes to the largest shareholder will result in a merged firm that prices higher and therefore in softer competitor in the product market. However,

[13] If we had not denoted the distributions of $\mu_i$, $\upsilon_i$ and $\theta_i$ equally, we would need to add the identification of variances and correlations.

with price competition, the outsiders reply with higher prices to the insiders' higher price. It follows that the two effects for the design of the optimal contract go again in the same direction. An equal distribution of shares increases diversification and results in less aggressive competition in the product market. Both effects boost profits in Bertrand competition. The optimal agreement will be, again, a merger of equals.

Davidson and Deneckere (1985) shows that, when risk-neutral firms compete in prices and the goods are substitutes, any merger is profitable. The next proposition shows that this result still holds when the firms are risk averse.[14]

**Proposition 3.4.** *Under Bertrand competition and demand uncertainty with substitute products and independent shocks, any merger is profitable.*

For consumers, mergers are never good when the goods are substitutes since both insiders and outsiders price higher than before the merger. When the goods are complements they may be better off when there is enough risk aversion. As in the Cournot case, non-merging firms price higher than before the merger exactly when their production is larger, and so are better off whenever $\gamma(1-\rho)R\sigma^2 \geq -k\gamma^2$. The outsiders profits always increase if the goods are substitutes, and if the goods are complements provided that risk aversion is not too high.

Social welfare may increase even when the goods are substitutes. However, as can be seen in the figure below, more risk aversion does not necessarily lead to higher welfare since consumers are made even worse off.

[Insert Figure 3 about here]

### 3.4.2 Bertrand competition with cost uncertainty

In this section we study price competition but with cost uncertainty. The analysis of this case is complicated by the fact that the variance of profits of a given firm is affected not only by the firm's actions but also by the rivals' actions.

[14] When the goods are complements, applying the duality to Proposition 3.2, more mergers are going to take place if the firms are risk averse. Also from the duality, in Cournot competition with complementary goods, any merger is profitable (Proposition 3.4).

### Prices

Following the same procedure as in Section 3.3, when no merger is produced in the first stage, all set the same price $p_i \equiv p$ for $i = 1...n$, where

$$p = \frac{\alpha(1+\beta R\sigma^2)}{2\beta - \gamma(n-1) + \beta R\sigma^2(\beta - (n-1)\gamma)}. \tag{3.9}$$

Here, as pointed out by Asplund (2002), higher levels of risk aversion leads to higher prices and hence softer competition.

When $k$ firms decide to merge in the first stage, the prices in equilibrium are

$$p_t = \frac{\alpha(1+\tau L)[\beta + (1+\beta R\sigma^2)(\beta+\gamma)]}{M(1+\tau L)+N} \text{ for } t = 1, ..., k \tag{3.10}$$

and

$$p_o = \frac{\alpha(1+R\sigma^2\beta)[\beta - \gamma(k-1) + (1+\tau L)(\beta+\gamma)]}{M(1+\tau L)+N} \text{ for } o = k+1, ..., n \tag{3.11}$$

where $M \equiv \beta[\beta - \gamma(k-1)] + (\beta+\gamma)(1+R\sigma^2\beta)[\beta - \gamma(n-1)]$, $N \equiv [\beta - \gamma(k-1)][\beta + [\beta - \gamma(n-k-1)](1+R\sigma^2\beta)]$ and $L \equiv R\sigma^2\,[1+\rho(k-1)][\beta - \gamma(k-1)]$. In this case, as the largest shareholder is made less risk averse through a reduction in its stake, the opponents become more aggressive and reply with lower prices.

From (3.9), (3.10) and (3.11), both insiders and outsiders price higher than pre-merger whenever the same condition is satisfied:

$$\beta R\sigma^2[1 - \tau(1+\rho(k-1))][\beta - \gamma(k-1)] \leq \gamma(k-1). \tag{3.12}$$

### Optimal contract

When designing the optimal contract, the two effects identified in Section 3.3 go in opposite directions. A more equal the division of shares has the benefit of increased diversification. But it also has the cost of inducing aggressive behavior in the product market, as the rivals reply to reduced insiders' prices by cutting prices and so lowering the insiders' profits. The optimal division of shares trades off these two effects:

**Proposition 3.5.** *Under Bertrand competition with cost uncertainty, the optimal sharing rule is neither the merger of equals nor the takeover. It gives $\tau^*(R\sigma^2, \beta, \gamma, \rho, n, k)$ shares of the new entity to one shareholder with $\tau^* \in (\frac{1}{k}, 1)$ whereas all the other shares are split equally among the rest.*

In the agreement, risk averse firms end up taking advantage of some of the diversification possibilities of the merger, even if this triggers aggressive competition in the product market. This has important consequences for consumer and social welfare.

**Private Incentives, Consumer and Social Welfare**

Contrary to what happened in the previous cases, the optimal sharing rule depends on the level of risk aversion. Substituting the optimal sharing rule in the insiders' utility level, we obtain that mergers are still profitable.

**Proposition 3.6.** *Under Bertrand competition and demand uncertainty (substitute products and independent shocks), any merger is profitable.*

To see the effect mergers on the price level and therefore on consumer welfare, we need to substitute the percentage of shares of the largest shareholder, $\tau^*$, into (3.12).

**Proposition 3.7.** *Under Bertrand competition and demand uncertainty (substitute products and independent shocks), a merger decreases prices and increases consumer welfare whenever* $R\sigma^2 \geq \widehat{R\sigma^2}$ *where* $\widehat{R\sigma^2}$ *is uniquely defined by* $\widehat{R\sigma^2}[1-\tau^*(\widehat{R\sigma^2})] = \frac{\gamma(k-1)}{\beta[\beta-\gamma(k-1)]}$.

When firms are sufficiently risk averse, competition is tougher and prices of both insiders and outsiders decrease following the merger. As we can see in the following figure, social welfare is also enhanced.

[Insert Figure 4 about here]

## 3.5 Discussion

In our model firms are assumed to be risk averse rather than, as typically assumed in oligopoly theory, risk neutral. In what follows, we discuss reasons for which firms might be risk averse or, act as if they were risk averse, even if they are risk neutral.

**Concentrated Ownership.** Many firms are controlled by single (or family) owners or large shareholders.[15] This is especially the case for medium and small firms, but

[15] According to Burkart et al. (2003): "Most firms in the world are controlled by their founders, or by the founders' families and heirs. Such family ownership is nearly universal among privately held firms, but also dominant among publicly traded firms."

even large corporations can have concentrated ownership structures in countries with less developed financial markets. Our model directly applies to firms fully controlled by single undiversified entrepreneurs, once the firm's objective function is identified with the owner's utility.

More generally, firms with undiversified shareholders, should care about profit variability. As confirmed by La Porta et al. (1999), controlling shareholders are present in most large companies. These controlling shareholders typically hold control rights well in excess of their cash flow rights (largely through the use of pyramids) and have an active role in management.[16] The firm's payoff should then be constructed to take into account the level of risk aversion of the undiversified shareholders.[17]

**Limited Hedging.** Even if ownership is concentrated and the firm is concerned about risk, hedging markets can help insuring against variability in profits. Transaction costs and moral hazard problems limit the insurability of risk, especially when a firm's payoff (on which it would like to hedge) crucially depends on the actions taken in the product market as well as on the realization of uncertainty.

To illustrate this, consider a quantity setting firm operating in a market with demand uncertainty. Suppose that hedging/insurance contracts can condition on the firm's verifiable revenues, but cannot be made contingent on the output set by the firm, its cost or the realization of demand. In this moral hazard environment, the firm will have to bear some risk, as otherwise it would have no incentive to produce a positive output.

**Managerial Control.** In modern widely held corporations, ownership is dispersed and shareholders can fully diversify risk. Decision making is then delegated to professional managers, who are given incentives to maximize profits. Managers are often paid depending on realized profits, and so will have to bear some of the firm's risk.

[16]The prevalence of concentrated ownership is somewhat puzzling. With perfect capital markets, shareholders should hold perfectly diversified portfolios, contrary to what is often observed. In reality, large shareholders have the opportunity of expropriating minority shareholders, as also suggested by La Porta et al.(1999).

[17]Note that as controlling shareholders actively participate in management, they might be willing to take less risk than it would be optimal for the totality of shareholders. Our welfare analysis could be extended to account for this divergence between the controlling shareholder's and the firm's objective function.

The sensitivity of managerial compensation to firm performance has indeed increased drastically since 1980, as documented by Hall and Liebman (1998).

Managerial moral hazard problems create the well-known trade off between risk sharing and incentives, as in the case of hedging discussed above. When risk averse managers are in control and are remunerated on the basis of firm profitability, they will sacrifice expected profits in order to reduce variability. As a result of managerial incentive problems, the firm will behave as if it is risk averse. Note that with this interpretation, the firm's payoff will typically differ from the manager's payoff, invalidating our welfare analysis.[18]

**Liquidity Constraints** Liquidity constraints and costs of financial distress can make the payoff functions of firms concave in profits and so generate risk averse like behavior.[19] When the cost of financing is higher with external sources than with internally generated funds, the firm's value of additional profits decreases in the level of profits. This concavity can be generated in models with informational asymmetries between managers and outside investors, along the lines of Bolton and Scharfstein (1990).

For example, in the banking industry banks' concerns with risk management can be attributed to the increasing costs of raising non-deposit external finance.[20] Consolidation can lower bank risk and reduce the probability of failure, as the risk of individual banks in the organization may decline as the other affiliates serve as a source of strength.[21]

**Stochastic Production** Competition between risk neutral firms with stochastic production is also equivalent to competition between risk-averse firms. To illustrate this, suppose that only a random fraction $s_i$ of firm $i$'s production reaches the market, so that firm $i$ sells $s_i q_i$ when producing $q$. Profits are then given by $\pi_i^S = (w - bs_i q_i -$

[18]The effect of mergers on consumers would be clearly unaffected, but the welfare analysis would need to be extended to account for the divergence of firm and managerial objectives.

[19]See Froot et al. (1993) for a comprehensve discusson of situations leading firms to hedge risk.

[20]As Froot and Stein (1998) puts it: "In an effort to avoid these costs, the bank will behave in a risk averse fashion".

[21]See Vander Vennet (1999) for an empirical analysis of mergers and acquisitions on the efficiency and profitability of European banks. He found that universal banks in Europe had both higher revenues and higher profitability, which could be attributed in part to improved risk diversification.

$d \sum_{j \neq i} s_j q_j) s_i q_i - c q_i$. Assuming that $s_i$ are independently identically distributed across firms, with support $[0, 1]$, expectation $\overline{s}$, and variance $\sigma_s^2$. Identifying $\overline{s} q_i$ with $x_i$, $\frac{\sigma_s^2}{\overline{s}}$ with $\frac{R}{2}\sigma^2$, $w - \frac{c}{\overline{s}}$ with $a$, we have that maximizing the expectation of $\pi_i^S$ is identical to solving (3.1). Note that profits decrease in the variance of the stochastic loss in production due to the concavity of profits in the quantity sold.

## 3.6 Conclusion

This paper is a first investigation on the private and social effects of horizontal mergers with risk averse firms. We have proposed a tractable model with mean variance preferences and a differentiated-product linear demand system. We have studied how the outcomes depend on whether competition is in quantities or prices, and on whether the uncertainty is about the intercept of the firms' demand or the level of marginal costs.

In a risk averse environment, a meaningful distinction emerges between mergers and takeovers. The division of shares of the new company has a direct effect on risk sharing and an indirect strategic effect. First, risk sharing improves when the shares of the individual merging firms are more equally responsive to risk, holding constant the strategies in the product market. In a merger of equals the decision maker is then exposed to less risk than in a takeover. Second, the division of shares affects strategic behavior in the product market. Indeed, even though a low exposure helps to behave aggressively in Cournot markets (or softly in Bertrand markets with demand uncertainty), it induces tough competition in markets with Bertrand competition and cost uncertainty. The optimal sharing rule is then a merger of equals, unless firms compete in prices under cost uncertainty. In that case, a hybrid between a proper merger and a complete acquisition is instead optimal.

We have found that more mergers take place in uncertain markets. If risk aversion is taken into account, firms have more incentives to merge in Cournot markets. As consolidation makes firms more aggressive, mergers involving few firms become profitable with a relatively small level of risk aversion. This can explain why we observe mergers in relatively unconcentrated industries. This can be seen as a resolution to the "merger paradox", according to which outsiders benefit but insiders are hurt from small mergers. As a result of their improved risk bearing, insiders can even increase their production above pre-merger levels at the expense of the outsiders (and to the benefit consumers). In price-setting markets, mergers among firms selling substitute goods are always profitable also in the presence of risk.

Because of the risk sharing effect identified here, mergers can result inefficiency gains.[22] In Cournot markets the level of uncertainty and risk aversion need to be quite large for mergers to be socially beneficial. In price setting markets consumers do not benefit from mergers with demand uncertainty, but can easily benefit in markets with cost uncertainty.

[22] For dicussions of the difficulties with efficiency defence see Farrell and Shapiro (1990) and Röller et al. (2001a).

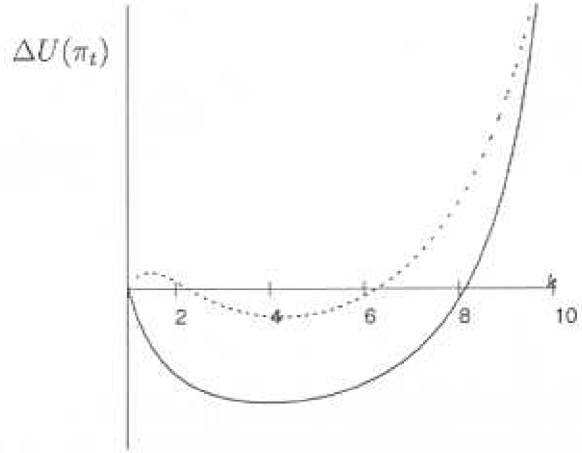


Figure 1: Incentives to merge in a Cournot market with risk neutral ($R\sigma^2 = 0$, thin line) and risk averse firms ($R\sigma^2 = 1$, dashed line) when $n = 10$, $b = d$ and $\rho = 0$.

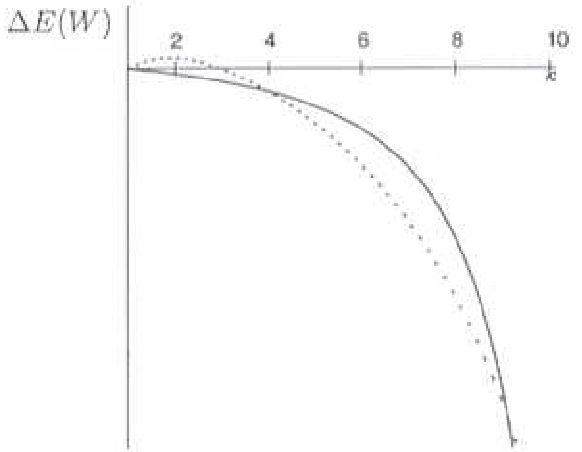


Figure 2: Social consequences of a merger in a Cournot market with risk neutral ($R\sigma^2 = 0$, thin line) and risk averse firms ($R\sigma^2 = 1$, dashed line) when $n = 10$, $b = d$ and $\rho = 0$.

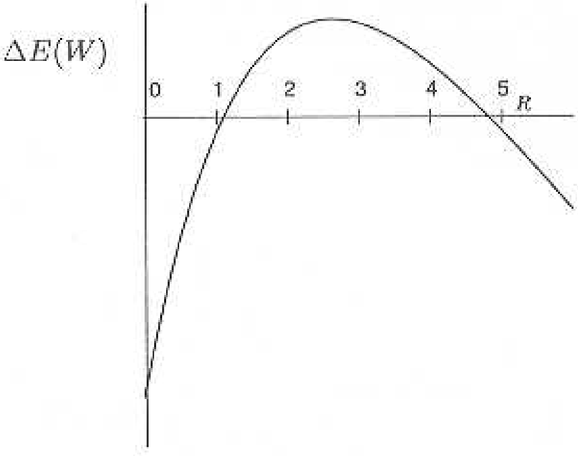


Figure 3: Social consequences of a merger in a Bertrand market with demand-side uncertainty with respect the level of risk aversion when $n = 10$, $\beta = 10$, $\gamma = 1$, $\sigma^2 = 1$ and $\rho = 0$.

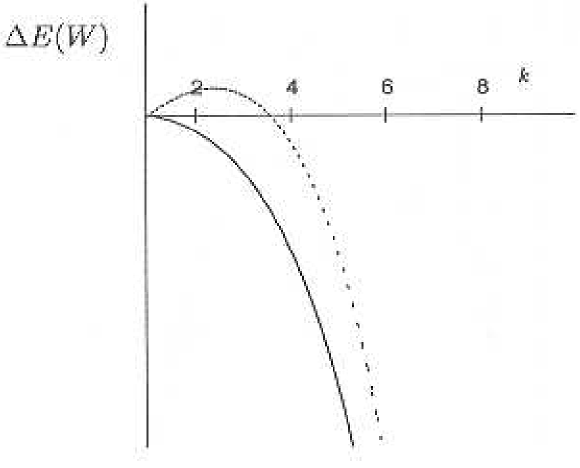


Figure 4: Social consequences of a merger in a Bertrand market with cost uncertainty with risk neutral ($R\sigma^2 = 0$, thin line) and risk averse firms ($R\sigma^2 = 0.01$, dashed line) when $n = 10$, $\beta = 10$, $\gamma = 1$, and $\rho = 0$.

# Appendix

## Appendix to Chapter 1

In this section we present the explicit expressions for the different cases in the propositions and their proofs. The proofs are given following a series of lemmas. We denote for simplicity $\Pi_j^m$ the (gross) profits for each manager in monopoly when $j$ managers invest; $\Pi_{j,l}^i$ and $\Pi_{l,j}^o$ the (gross) profits for each insider and outsider manager, respectively, when $j$ insiders and $l$ outsiders invests; and $\Pi_{1,j}^t$ and $\Pi_{0,j}^t$ the (gross) profits for each triopolist when he invests and when he does not, respectively, in the case the other $j$ triopolists invest $(j = 0, 1, 2)$. Similarly we denote $\pi^m$, $\pi^i$, $\pi^o$and $\pi^t$ the 'net' profits for each monopolist, insider, outsider and triopolist.

### Proof of Proposition 1.3

Within each firm, it is always always optimal for the managers to choose a corner solution, where none of them invests or all of them do. Managers in a monopoly invest if and only if $c \leq \overline{c}^m$ where $\overline{c}^m$ is implicitly defined by $\Pi_3^m - \overline{c}^m = \Pi_0^m$. When there is competition, firms condition their investment decisions to those of the rivals. In a duopoly, insiders' decision depends on the decision of the outsider and vice versa. The insiders invest if $c \leq \overline{c}_1^i$ and if $c \leq \overline{c}_0^i$ depending, respectively, whether the outsider invest or not, where $\Pi_{2,1}^i - \overline{c}_1^i = \Pi_{0,1}^i$ and $\Pi_{2,0}^i - \overline{c}_0^i = \Pi_{0,0}^i$. Similarly, the outsider invest if $c \leq \overline{c}_2^o$ and if $c \leq \overline{c}_0^o$ depending, respectively, whether the insiders invest or not, where $\Pi_{1,2}^o - \overline{c}_2^o = \Pi_{0,2}^o$ and $\Pi_{1,0}^i - \overline{c}_0^o = \Pi_{0,0}^o$. Finally, each triopolist invests if $c \leq \overline{c}_j^t$, where $\Pi_{1,j}^t - \overline{c}_j^t = \Pi_{0,j}^t$.

**Lemma 1.9.** *The relevant cutoffs are ordered as follows:* $\overline{c}_2^t < \overline{c}_1^t < \overline{c}_0^t < \overline{c}^i$; $\overline{c}^o < \overline{c}^i$; $\overline{c}_0^t < \overline{c}^m$ *and* $\overline{c}^o < \overline{c}^m$ *where for simplicity we denote* $\overline{c}^i \equiv \overline{c}_0^i$ *and* $\overline{c}^o \equiv \overline{c}_2^o$.

*Proof.* By definition, the cutoff points for the triopolists are $\overline{c}_2^t = \frac{3k(2-k)}{16}$, $\overline{c}_1^t = \frac{3k(2+k)}{16}$ and $\overline{c}_0^t = \frac{3k(2+3k)}{16}$. In a duopoly, $\overline{c}_1^i = \frac{4k(1+k)}{9}$, $\overline{c}_0^i = \frac{4k(1+2k)}{9}$, $\overline{c}_2^o = \frac{4k(1-k)}{9}$ and $\overline{c}_0^o = \frac{4k(1+k)}{9}$. Notice that $\overline{c}_0^o$ is not relevant. In the region where the outsider does invest only if the insiders do not ($\overline{c}_2^o < c < \overline{c}_0^o$), the latter always invest ($\overline{c}_0^i > \overline{c}_1^i = \overline{c}_0^o$). Similarly, $\overline{c}_1^i$ is not relevant because when the insiders would stop investing if the outsider invested, the latter never invests. Finally, in a monopoly, $\overline{c}^m = \frac{k(2+3k)}{4}$. The ordering follows from straightforward algebra. □

The following lemma characterizes the four different regions in Proposition 1.3.

**Lemma 1.10.** *The investment decision levels are the following.*

*a) If* $c \leq \min\{\overline{c}^o, \overline{c}_2^t\}$ *all managers in all firms invest.*

*b) If* $\min\{\overline{c}^o, \overline{c}_2^t\} < c \leq \min\{\overline{c}^i, \overline{c}^m\}$*, managers in the monopoly and insiders in a duopoly invest but single-manager firms may not.*

*c) If* $\min\{\overline{c}^i, \overline{c}^m\} < c \leq \max\{\overline{c}^i, \overline{c}^m\}$*, either the insiders or the monopolists invest while the rest never does. If* $k \leq \frac{2}{5}$ *we have that* $\overline{c}^i \leq \overline{c}^m$ *and only the monopolists invest whereas if* $k > \frac{2}{5}$ *we have that* $\overline{c}^i > \overline{c}^m$ *and only the insiders invest.*

*d) If* $c > \max\{\overline{c}^i, \overline{c}^m\}$*, no manager invests.*

*Proof.* a) and d) From Lemma 1.9, if $c \leq \min\{\overline{c}^o, \overline{c}_2^t\}$ all the cutoffs are above and hence all firms invest whereas if $c > \max\{\overline{c}^i, \overline{c}^m\}$ all the cutoffs are below and hence no manager invests.

b) In this region, by definition, the insiders and the monopolists invest. Within the region, as $c$ increases the single-manager firms stop investing gradually (in different order depending on $k$).

c) From Lemma 1.9 the cutoffs for all single-manager firms are below and hence they never invest. Straightforward algebra shows that when $k \leq \frac{2}{5}$ we have that $\overline{c}^i \leq \overline{c}^m$ and therefore only the monopolists invest whereas when $k > \frac{2}{5}$ then $\overline{c}^i > \overline{c}^m$and only the insiders invest. □

## Proof of Proposition 1.4

Each manager in a monopoly invests as long as $c \leq \widetilde{c}_j^m$ when $j$ other managers invest ($j = 0, 1, 2$), where $\Pi_{j+1}^m - \widetilde{c}_j^m = \Pi_j^m$. When the outsider invests in the duopoly, each insider invests if $c \leq \widetilde{c}_{j,1}^i$ depending whether the other insider invests or not ($j = 0, 1$) where $\Pi_{j+1,1}^i - \widetilde{c}_{j,1}^i = \Pi_{j,1}^i$. Similarly, when the outsider does not invest, the cutoff points are $\widetilde{c}^{i}_{j,0}$ $(j=0,1)$ with the analogous definitions. The cutoff values for the single-manager firms are the same as in the proof of Proposition 1.3, $\widetilde{c}^{o}_{j}=\overline{c}^{o}_{j}$ and $\widetilde{c}^{t}_{j}=\overline{c}^{t}_{j}$.

**Lemma 1.11.** *The relevant cutoffs are ordered as follows: $\widetilde{c}^{t}_{2}<\widetilde{c}^{t}_{1}<\widetilde{c}^{t}_{0}<\widetilde{c}^{o}_{0}$; $\widetilde{c}^{m}<\widetilde{c}^{t}_{1}$; $\widetilde{c}^{m}<\widetilde{c}^{i}_{1}<\widetilde{c}^{i}_{0}<\widetilde{c}^{t}_{0}$; $\widetilde{c}^{o}_{2}<\widetilde{c}^{o}_{0}$ and $\widetilde{c}^{i}_{1}<\widetilde{c}^{t}_{1}$ where for simplicity we denote $\widetilde{c}^{m}\equiv\widetilde{c}^{m}_{2}$ and $\widetilde{c}^{i}_{j}\equiv\widetilde{c}^{i}_{1,j}$.*

*Proof.* In the monopoly structure, $\widetilde{c}^{m}_{0}=\frac{k(2+k)}{12}$, $\widetilde{c}^{m}_{1}=\frac{k(2+3k)}{12}$ and $\widetilde{c}^{m}_{2}=\frac{k(2+5k)}{12}$. We have that all the managers investing is an equilibrium whenever $c\leq\widetilde{c}^{m}_{2}$ whereas no manager investing is an equilibrium whenever $c>\widetilde{c}^{m}_{0}$. Between $\widetilde{c}^{m}_{0}$ and $\widetilde{c}^{m}_{2}$ both equilibrium coexist but the former is chosen because it Pareto dominates the latter. Then $\widetilde{c}^{m}_{0}$ and $\widetilde{c}^{m}_{1}$ are not relevant. In the duopoly structure, the cutoffs for the insiders are $\widetilde{c}^{i}_{0,0}=\frac{2k(1+k)}{9}$, $\widetilde{c}^{i}_{0,1}=\frac{2k}{9}$, $\widetilde{c}^{i}_{1,0}=\frac{2k(1+3k)}{9}$ and $\widetilde{c}^{i}_{1,1}=\frac{2k(1+2k)}{9}$. The same argument as in the monopoly case applies here and only the cutoffs in which the partner invests are relevant. In turn, the relevant cutoffs for the outsiders are the ones in which none or all the insiders invest. The cutoffs for the outsider and the triopolists are obtained in the proof of the previous proposition. Straightforward algebra leads to the ordering. □

**Lemma 1.12.** *The investment decision levels are the following.*

*a) If $c\leq\widetilde{c}^{m}$ the managers in the monopoly and the insiders in the duopoly invest.*

*b) If $\widetilde{c}^{m}<c\leq\widetilde{c}^{i}_{1}$ or $\max\{\widetilde{c}^{i}_{1},\widetilde{c}^{o}_{2}\}<c\leq\widetilde{c}^{i}_{0}$ there is an equilibrium in which the insiders in the duopoly invest whereas the managers in the monopoly never invest.*

*c) If $\widetilde{c}^{i}_{1}<c\leq\min\{\widetilde{c}^{o}_{2},\widetilde{c}^{i}_{0}\}$ and $\widetilde{c}^{i}_{0}<c\leq\widetilde{c}^{o}_{0}$ the insiders and the monopolists never invest and at least one single-manager firm invests.*

*d) If $c>\widetilde{c}^{o}_{0}$ nobody invests.*

*Proof.* a) We can distinguish two subcases: a.1) When $c\leq\min\{\widetilde{c}^{m},\widetilde{c}^{o}_{2}\}$, from Lemma 1.11, all the managers invest because all the cutoffs are above. a.2) When $\widetilde{c}^{o}_{2}\leq c<\widetilde{c}^{m}$ the outsider does not invest by definition and there may be a triopolist that does not invest (when $\widetilde{c}^{t}_{2}\leq c<\widetilde{c}^{m}$). In other situations, all managers invest.

b) Here the monopolists stop investing. Again we can distinguish two subcases: b.1) when $\widetilde{c}^{m}<c\leq\widetilde{c}^{i}_{1}$ the insiders always invest independent of the outsider decision. From Lemma 1.11, depending on the combination of parameters, the outsider may or may not invest whereas there are two or three triopolists doing so. b.2) If

$\max\{\widetilde{c}_1^i, \widetilde{c}_2^o\} < c \leq \widetilde{c}_0^i$ there are two possible equilibria in the duopoly: either the insiders do invest and the outsider does not or vice versa. Again from Lemma 1.11 we can check that there might be one or two triopolists investing.

c) Here the insiders and the monopolists never invest. We distinguish five subcases: c.1) when $\widetilde{c}_1^i < c \leq \widetilde{c}_2^t$ the three triopolists and the outsider invest, c.2) when $\max\{\widetilde{c}_2^t, \widetilde{c}_1^i\} < c \leq \min\{\widetilde{c}_2^o, \widetilde{c}_1^t\}$ or when $\max\{\widetilde{c}_2^o, \widetilde{c}_0^i\} < c \leq \widetilde{c}_1^t$ two triopolist and the outsider invest, c.3) when $\max\{\widetilde{c}_1^t, \widetilde{c}_0^i\} < c \leq \widetilde{c}_0^t$ one triopolist and the outsider invests, c.4) when $\widetilde{c}_0^t < c \leq \widetilde{c}_0^o$ only the outsider invest and c.5) when $c > \widetilde{c}_0^o$ no one invests. □

## Proof of Proposition 1.5

In the following lemma, we show that in our game we cannot have multiple stable regions when there is no conflict .

**Lemma 1.13.** *For any combination of parameters, there is at most one stable structure.*

*Proof.* Remember that we denote $\pi^m$, $\pi^i$ and $\pi^o$ the 'net' profits for each monopolist, insider and outsider (the equilibria in investment are unique). In order to consider all the possible cases in the triopoly, denote $\pi_a^t \geq \pi_b^t \geq \pi_c^t$ the net profits obtained by each triopolist. In what follows we state the conditions needed to ensure stability. The monopoly is stable when: (1) $\pi^m \geq \pi^i$ and (2) if $\pi_b^t \leq \pi^i$ then $\pi^m \geq \pi^o$ whereas if $\pi_b^t > \pi^i$ then $\pi^m \geq \pi_a^t$ (remember that the deviator is always "optimistic"). The duopoly is stable when (3) $\pi^i > \pi^m$ or $\pi^o > \pi^m$ and (4) if $\pi_b^t \leq \pi^i$ then $\pi^i \geq \pi^o$ whereas if $\pi_b^t > \pi^i$ then $\pi^i \geq \pi_a^t$. The second part of condition (4) is never satisfied ($\pi_a^t \geq \pi_b^t$) and hence condition (4) can be rewritten as (4') both $\pi_b^t \leq \pi^i$ and $\pi^i \geq \pi^o$ should hold. Finally, the triopoly is stable whenever (5) $\pi_a^t > \pi^m$ and (6) $\pi_b^t > \pi^i$.

We are going to show the result by contradiction. Suppose firstly that the monopoly and the duopoly are stable at the same time. From (1) and (3), we get that $\pi^o > \pi^m$ and from (2) and (4') that $\pi^m \geq \pi^o$ and hence a contradiction. Secondly, the duopoly and the triopoly can not be simultaneously stable structures because (4') and (6) can not be satisfied at the same time. Finally, suppose that the monopoly and the triopoly are stable structures. From (2) and (6) we obtain that $\pi^m \geq \pi_a^t$ which is in contradiction with (5). □

Thanks to the following lemma, we know that the triopoly will never be a stable structure.

**Lemma 1.14.** *Managers always prefer the monopoly to the triopoly.*

*Proof.* Suppose firstly that the monopolists do not invest. By Lemma 1.9 none of the triopolists invests either. Since $\Pi_0^m = \frac{1}{12} > \frac{1}{16} = \Pi_{0,0}^t$ the monopoly is always preferred. Next suppose that a given manager invests both in monopoly and in triopoly. Again, the monopoly is always preferred since $\Pi_3^m = \frac{(1+3k)^2}{12} > \frac{(1+3k)^2}{16} = \Pi_{1,0}^t > \Pi_{1,1}^t > \Pi_{1,2}^t$. Last, take the case in which a manager would invest as a monopolist but not as a triopolist. He would prefer a monopoly to a triopoly in which none of the other triopolists invests when $\Pi_3^m - c > \Pi_{0,0}^t$ or in other words when $c < \frac{1+24k+36k^2}{48}$. This is always the case in this region since $c < \overline{c}^m < \frac{1+24k+36k^2}{48}$. When there are one or two other triopolists investing, the monopoly is even more preferred. □

**Lemma 1.15.** *Managers prefer the monopoly than being insiders in a duopoly.*

*Proof.* First suppose that a given manager invests both in the monopoly and being insider in a duopoly. Since $\Pi_3^m = \frac{(1+3k)^2}{12} > \frac{(1+4k)^2}{18} = \Pi_{2,0}^i > \Pi_{2,1}^i$, the insiders would never deviate from a monopoly. Second, he always prefers the monopoly whenever he does not invest in either situation because $\Pi_0^m = \frac{1}{12} > \frac{1}{18} = \Pi_{0,0}^i > \Pi_{0,1}^i$. Third, take the case in which he would invest in the monopoly but not in the duopoly (from Lemma 1.9 the outsider does not invest in this region either). The monopoly is preferred whenever $\Pi_3^m - c > \Pi_{0,0}^i$ or in other words when $c < \frac{1+18k+27k^2}{36}$. This is always the case here since $c < \overline{c}^m < \frac{1+18k+27k^2}{36}$. Finally suppose that as an insider he would invest but not as a monopolist (again the outsider does not invest). He prefers the monopoly as long as $\Pi_0^m > \Pi_{2,0}^i - c$ or $c > \frac{-1+16k+32k^2}{36}$. Since $c > \overline{c}^m > \frac{-1+16k+32k^2}{36}$ this is always the case in this region. □

**Lemma 1.16.** *The monopoly is the unique stable structure when being in a monopoly is better than being an outsider ($\pi^m \geq \pi^o$) or when insiders in a duopoly would break for triopoly ($\pi_b^t > \pi^i$) . Otherwise, no industry structure is stable.*

*Proof.* Each one of these conditions, together with Lemma 1.14 and Lemma 1.15, ensure that conditions (1) and (2) in the proof of Lemma 1.13 are satisfied and hence the monopoly is the (unique) stable structure. We show the second statement by contradiction. Suppose firstly that these conditions are not satisfied and that the duopoly is stable. From Lemma 1.13 the duopoly could only be stable when the monopoly is not or in other words when $\pi_b^t \leq \pi^i$ and $\pi^o > \pi^m$. From Lemma 1.15 we have that $\pi^m > \pi^i$ and hence $\pi^i \geq \pi^o$. This contradicts the condition (4') in the proof of Lemma 1.13. Secondly, from Lemma 1.14 the triopoly is never stable. $\square$

**Lemma 1.17.** *When there is no internal conflict within firms, the monopoly is the only stable structure. No stable structure exists when* $(c, k)$ *are such that* $k_1 \leq k < k_2$ *and* $c \leq \overline{c}_2^t$*, where* $k_1 = \frac{4\sqrt{2}-5}{21}$ *and* $k_2 = \frac{2\sqrt{3}-3}{3}$.

*Proof.* We are going to prove this lemma following the four parts identified in Lemma 1.10:

a) We have that $\pi^t = \Pi_{1,2}^t - c > \Pi_{2,1}^i - c = \pi^i$ whenever $k < k_1 = \frac{4\sqrt{2}-5}{21}$ and that $\pi^m = \Pi_3^m - c \geq \Pi_{1,2}^o - c = \pi^o$ whenever $k \geq k_2 = \frac{2\sqrt{3}-3}{9}$. From Lemma 1.16 the monopoly is stable if $k < k_1$ or $k \geq k_2$ whereas if $k_1 \leq k < k_2$ no industry structure is stable.

b) We are going to show that at least one of the two conditions in Lemma 1.16 is satisfied. On the one hand we show that when $k \geq \frac{1}{15}$ we have that $\pi^m \geq \pi^o$. If the outsider does invest, $\pi^m = \Pi_3^m - c \geq \Pi_{1,2}^o - c = \pi^o$ when $k \geq k_2$ and in particular when $k \geq \frac{1}{15}$. If the outsider does not invest, $\pi^m = \Pi_3^m - c \geq \Pi_{0,2}^o = \pi^o$ when $c \leq \frac{-1+34k+11k^2}{36}$. This inequality is always satisfied when $k \geq \frac{1}{15}$ and $c < \overline{c}^i$.

On the other hand we show that when $k < \frac{1}{15}$ we have that $\pi_b^t > \pi^i$. Take first the case in which no triopolist invests ($c > \overline{c}_0^t$). We have that $\pi^t = \Pi_{0,0}^t > \Pi_{2,0}^i - c$ (and in particular that $\pi^t > \Pi_{2,1}^i - c$) whenever $c > \frac{-1+64k+128k^2}{144}$. This is always satisfied when $k < \frac{1}{15}$ and $c > \overline{c}_0^t$. Second consider the case where only one triopolist invests. From the definition of the cutoffs (see proof of Lemma 1.9), the outsider always invests in this region when we impose $k < \frac{1}{15}$. In addition, we have that $\pi_b^t = \Pi_{0,1}^t$. We have that $\pi_b^t = \Pi_{0,1}^t > \Pi_{2,1}^i - c = \pi^i$ whenever $c > \frac{-1+66k+63k^2}{144}$. This is always satisfied when $k < \frac{1}{15}$ and $c > \overline{c}_1^t$. Last take the case in which two triopolists invest (again here the outsider would invest). In this case $\pi_b^t = \Pi_{1,1}^t$ and $\pi_b^t = \Pi_{1,1}^t - c > \Pi_{2,1}^i - c = \pi^i$ whenever $k < \frac{\sqrt{2}-1}{6}$ and in particular when $k < \frac{1}{15}$.

c) In the part of this region where only the monopolists invest we have that $\pi^t = \Pi_{0,0}^t > \Pi_{0,0}^i = \pi^i$ and hence the monopoly is the stable structure. When the insiders invest, we have that $\pi^t = \Pi_{0,0}^t > \Pi_{2,0}^i - c = \pi^i$ whenever $c > \frac{-1+64k+128k^2}{144}$. This condition is always satisfied since $c > \overline{c}^m \geq \frac{-1+64k+128k^2}{144}$.

d) Similar to the first part of part c), the monopoly is stable since $\pi^t = \Pi^t_{0,0} > \Pi^i_{0,0} = \pi^i$. $\square$

## Proof of Proposition 1.6

In this and in the following proofs we are going to use, when possible, Lemma 1.13. In fact, it applies as long as there is not multiplicity of equilibria in the duopoly investment decisions. As we have seen in the proof of Lemma 1.12 the region (a) can be divided in two parts.

a.1) When any manager in any situation invests, the stable structures and the proofs are identical to those of Proposition 1.5 when everyone was investing.

a.2) The monopoly is stable because it is preferred to any other position in any other industry structure. We have that $\pi^m = \Pi^m_3 - c > \Pi^i_{2,0} - c = \pi^i$ and that $\pi^m > \Pi^t_{1,1} - c > \Pi^t_{1,2} - c$ and hence managers prefer the monopoly to being insiders and being triopolists investing (independent of being two or three of them doing so). They prefer the monopoly to being outsiders when $\pi^m \geq \Pi^o_{0,2} = \pi^o$ or when $c \leq \frac{-1+34k+11k^2}{36}$ and the monopoly to being triopolists not investing when $\pi^m \geq \Pi^t_{0,2}$ or when $c \leq \frac{1+36k+24k^2}{48}$. These two conditions are always satisfied in this region ( $\widetilde{c}^o_2 \leq c < \widetilde{c}^m$). Thus, the monopoly is stable and from Lemma 1.13 it is unique.

## Proof of Proposition 1.7

As we have seen in the proof of Lemma 1.12 this region can be divided in two parts.

b.1) Here the uniqueness result still applies. Managers prefer being insiders than monopolists whenever $c \leq c_1(k) = \frac{-1+12k+18k^2}{36}$: when the outsider invests $\pi^i = \Pi^i_{2,1} - c > \Pi^m_0 = \pi^m$ precisely when $c \leq c_1(k)$ whereas when he does not we have that $\pi^i = \Pi^i_{2,0} - c > \Pi^m_0 = \pi^m$ is always satisfied in this region. In addition, $\pi^i \geq \pi^t_b$ independent of the number of triopolists investing and of the choice of the outsider. They also prefer to be an insider than an outsider, $\pi^i \geq \pi^o$, independent of the outsider investment decision. This three conditions are necessary and sufficient to ensure duopoly stability (see proof of Lemma 1.13).

When $c > c_1(k)$, we have that managers in a monopoly do not invest whereas in any other situation all managers invest (see proof of Lemma 1.12). Managers prefer the monopoly to being insiders by definition. They also prefer the monopoly to the triopoly $\pi^m = \Pi^m_0 > \Pi^t_{1,2} - c = \pi^t$ and hence the triopoly is never stable.

Choices between monopoly and outsider and between insider and triopoly are going to determine three different regions. Managers prefer being monopolists than outsiders whenever $c \geq c_2 = \frac{1}{36}$ and they prefer being insiders to triopolists whenever $k \geq k_1$ (see proof of Proposition 1.5). This defines three regions because: (a) $c_1'(k) > 0$ and the $k^*$ such that $c_1(k^*) = \widetilde{c}_1^i(k^*)$ is larger than the $k^{**}$ such that $c_2 = \widetilde{c}_1^i(k^{**})$ and (b) the $k^{***}$ such that $c_2 = \widetilde{c}_0^i(k^{***})$ is larger than $k_1$. In the first region, when $k \leq k_1$, the monopoly is stable because condition (1) and the second part of (2) are satisfied. In the second region, when $k \geq k_1$ and $c < c_2$ no structure is stable. The monopoly is not stable because condition (2) is not satisfied and the duopoly is not stable because managers prefer being outsiders than insiders ($\pi^o > \pi^m \geq \pi^i$) breaking condition (4'). Finally, when $c \geq c_2$ (and $c > c_1(k)$) the monopoly is stable because condition (1) and the first part of (2) are satisfied.

b.2) There are two different equilibria in the duopoly (Lemma 1.12): either the two insiders or the outsider invest. The profits in the investing equilibrium are always higher than in the non-investing one for both the insiders and the outsider ($\Pi_{2,0}^i - c \geq \Pi_{0,1}^i$ and $\Pi_{1,0}^o - c \geq \Pi_{0,2}^o$). Denoting the net profits in the insiders-investing equilibrium as $\pi_d^i$ and $\pi_d^o$ and in the outsider-investing one as $\pi_e^i$ and $\pi_e^o$, we have that $\pi_d^i > \pi_e^i$ and $\pi_d^o < \pi_e^o$.

We restate the stability conditions in order to accommodate this multiplicity. The monopoly is stable when: (M1) $\pi^m \geq \pi_d^i$ and (M2) if $\pi_b^t \leq \pi_e^i$ then $\pi^m \geq \pi_e^o$ whereas if $\pi_b^t > \pi_e^i$ then $\pi^m \geq \pi_a^t$. The insiders-investing duopoly is stable when (M3) $\pi_d^i > \pi^m$ or $\pi_d^o > \pi^m$ and (M4) if $\pi_b^t \leq \pi_e^i$ then $\pi_d^i \geq \pi_e^o$ whereas if $\pi_b^t > \pi_e^i$ then $\pi_d^i \geq \pi_a^t$. The outsiders-investing duopoly is stable when (M5) $\pi_e^i > \pi^m$ or $\pi_e^o > \pi^m$ and (M6) if $\pi_b^t \leq \pi_e^i$ then $\pi_e^i \geq \pi_e^o$ whereas if $\pi_b^t > \pi_e^i$ then $\pi_e^i \geq \pi_a^t$. The second part of condition (M6) is never satisfied ($\pi_a^t \geq \pi_b^t$) and hence condition (M6) can be rewritten as (M6') both $\pi_b^t \leq \pi_e^i$ and $\pi_e^i \geq \pi_e^o$ should hold. Finally, the triopoly is stable whenever (M7) $\pi_a^t > \pi^m$ and (M8) $\pi_b^t > \pi_d^i$.

Now we are going to show that the insiders-investing duopoly is stable. Firstly $\pi_d^i = \Pi_{2,0}^i - c > \Pi_0^m = \pi^m$ whenever $c \leq \frac{-1+16k+32k^2}{36}$ which is always true in this region. Hence condition (M3) is satisfied. We also have that $\pi_b^t > \pi_e^i$ independent of having one or two triopolists investing. If there is one clearly $\pi_b^t = \Pi_{0,1}^t > \Pi_{0,1}^i = \pi_e^i$ whereas if there are two $\pi_b^t = \Pi_{1,1}^t - c > \Pi_{0,1}^i = \pi_e^i$ whenever $c \leq \frac{1+52k+28k^2}{144}$ which is always true when $c < \widetilde{c}_1^t$. Finally, the condition $\pi_d^i > \pi_a^t$ is also satisfied since $\pi_d^i = \Pi_{2,0}^i - c > \Pi_{1,0}^t - c > \Pi_{1,1}^t - c$ in this region (as a triopolist, it is always better to be investing). The second part of condition (M4) is satisfied and hence this structure is stable.

This is the unique stable structure. The monopoly is not stable because, as we have seen, $\pi_d^i > \pi^m$ in contradiction with (M1). The outsider-duopoly is not stable either because $\pi_b^t > \pi_e^i$ and hence condition (M6') does not hold. Finally, the triopoly is not stable because $\pi_d^i > \pi_a^t \geq \pi_b^t$ contradicts condition (M8).

## Proof of Proposition 1.8

As we have seen in the proof of Lemma 1.12 this region (c) can be divided in five parts. Here the uniqueness result applies. Managers clearly prefer to be monopolists rather than insiders ($\pi^m = \Pi_0^m > \Pi_{0,0}^i > \Pi_{0,1}^i$). We also have that $\pi_b^t > \pi^i$ everywhere except when there are three triopolists investing (case c.1) where this is true only when $c < c_3(k) = \frac{1+34k+k^2}{144}$. Indeed, when there are three triopolists investing this is the condition such that $\pi_b^t = \Pi_{1,2}^t - c > \Pi_{0,1}^i = \pi^i$. When there are two investing we have that $\pi_b^t = \Pi_{1,1}^t - c > \Pi_{0,1}^i = \pi^i$ whenever $c < \frac{1+52k+28k^2}{144}$ which is always the case when $c < \widetilde{c}_1^t$. Clearly, when there is only one $\pi_b^t = \Pi_{0,1}^t > \Pi_{0,1}^i = \pi^i$ (the outsider always invests) and where there is none $\pi_b^t = \Pi_{0,0}^t > \Pi_{0,0}^i > \Pi_{0,1}^i$.

On the other hand, we have that $\pi^m \geq \pi_a^t$ in all cases except when there is only one triopolist investing where this is true only when $c > c_4(k) = \frac{-1+18k+27k^2}{48}$. Indeed, when there is only one triopolist investing this is the condition such that $\pi^m = \Pi_0^m \geq \Pi_{1,0}^t - c = \pi_a^t$ (we can check that the it is better to be the one investing). When there are two investing we have that $\pi^m = \Pi_0^m \geq \Pi_{1,1}^t - c = \pi_a^t$ whenever $c > \frac{-1+12k+12k^2}{48}$ and this is satisfied when $c > \widetilde{c}_1^i$. Therefore they also prefer the monopoly to being triopolist when the three invest. When none of the triopolists invests, clearly $\pi^m = \Pi_{0,0}^m > \Pi_{0,0}^t = \pi^t$.

Hence in all region c) except when there are three triopolists investing and $c \geq c_3(k)$ or when there is one triopolist investing and $c \leq c_4(k)$, the monopoly is the unique stable structure. Conditions (1) and (2) in the proof of Lemma 1.13 are satisfied.

When there is one triopolist investing and $c \leq c_4(k)$ the triopoly is the unique stable structure. In this region we have seen that $\pi_a^t > \pi^m$ and, as before, $\pi_b^t > \pi^i$ satisfying conditions (5) and (6).

Finally, when there are three triopolists investing and $c \geq c_3(k)$ there is no stable structure. We have that $\pi^o = \Pi^o_{1,0} - c > \Pi^m_0 = \pi^m$ when $c < \frac{1+10k+7k^2}{18}$ and $\pi^o = \Pi^o_{1,0} - c > \Pi^i_{0,1} = \pi^i$ when $c < \frac{1+16k+16k^2}{36}$. These two conditions hold when $c < \tilde{c}^t_2$. Then, since $\pi^t_b \leq \pi^i$, the monopoly is not stable because it would contradict condition (2). The duopoly is not stable either because $\pi^o > \pi^i$ contradicts condition (4'). Lastly, the triopoly is not stable because we have showed that $\pi^m \geq \pi^t_a$, which is in contradiction with condition (5).

# Appendix to Chapter 2: (A) Maximum variance

It has been assumed throughout the paper that no firm is driven out of the market and that the merged firm does not close any of its plants. This assumption is not innocuous. For any combination of the parameters, this condition fixes an upper bound on the variance. In this section I identify the maximum variance for the private information part of the basic model.

If no firm has merged, from (2.3), no firm will close if it is assumed that $x_j(\theta_{max}) \geq 0$. Similarly, if the merger has taken place, from (2.5), no outsider is driven out of the market if $x_o(\theta_{max}) \geq 0$ whereas from (2.4), the merged entity will not close any of its plants if $x_1(\theta_{max}, \theta_{min}, \ldots, \theta_{min}) \geq 0$. The latter condition is tighter than the former two. Thus, if the parameters satisfy this condition, it is ensured that, for any realization of the random variables and independently of the merger decision, all firms (and plants) will produce a positive amount. Rearranging this restriction and defining $T \equiv \theta_{max} - \theta_{min}$ and $qT \equiv \theta_{max} - \overline{\theta}$, the maximum length of the support is

$$T_{max}(q) = \frac{\lambda(1+\lambda)(2k+\lambda)}{[2(k-1)+q\lambda]S}(a-\overline{\theta}), \tag{2.13}$$

where for notational simplicity

$$S = (2k+\lambda)(1+\lambda) + (n-k)(k+\lambda).$$

By definition, the maximum variance of a random variable defined on a support of length $T$ is $\sigma^2_{max} = q(1-q)T^2$, where $q$ is defined above. Substituting (2.13) in this expression, and maximizing with respect to $q$, we have that

$$\sigma^2_{max} = \frac{\lambda^2(1+\lambda)^2(2k+\lambda)^2}{8(k-1)[2(k-1)+\lambda]S^2}(a-\overline{\theta})^2.$$

In the example depicted in Figure 3, where $(a - \overline{\theta}) = 10$, $\lambda = 4$ and $k = 2$, we have that $\sigma^2_{max} = 0.689$ for industries with ten or less firms. Similarly in Figure 4, where $(a - \overline{\theta}) = 10$, $\lambda = 8$ and $k = 2$, we have that $\sigma^2_{max} = 0.183$ for industries with eighty firms.

# Appendix to Chapter 2: (B) Proofs

## Proof of Lemma 2.1

Taking expectations in (2.2), the expected profits of the merged entity can be written as $E(\pi_M) \equiv g^D_M + g^U_M$, where substituting (2.4) and (2.5),

$$g^D_M(n,k) = \frac{(1+\lambda)^2(2k+\lambda)k}{2S(n,k)^2}\,(a-\overline{\theta})^2, \tag{2.14}$$

and

$$g^U_M(n,k) = \frac{[2(k-1)+\lambda]k}{2\lambda(2k+\lambda)}\,\sigma^2_\theta. \tag{2.15}$$

The expected profits when firms remain independent are $E(\pi_N) \equiv g^D_N + g^U_N$ where $g_N(n) = g_M(n,1)$. Straightforwardly, since $g_I = \frac{g_M}{k}$,

$$\Delta g^D_I = \frac{1}{2}\left[\frac{(1+\lambda)^2(2k+\lambda)}{S^2} - \frac{2+\lambda}{(n+\lambda+1)^2}\right](a-\overline{\theta})^2, \tag{2.16}$$

and

$$\Delta g^U_I = \frac{2(k-1)}{\lambda(2+\lambda)(2k+\lambda)}\,\sigma^2_\theta. \tag{2.17}$$

## Proof of Proposition 2.2

The change in expected profits in the equivalent deterministic market ($\sigma^2_\theta = 0$) is given by (2.16). This expression has the same zeros (and the same sign) in $n$ as $D(n) = (1+\lambda)^2(2k+\lambda)(n+\lambda+1)^2 - (2+\lambda)S(n,k)^2$. Since $D(n)$ is a quadratic function with $D''(n) = -2(k-1)[(2+\lambda)k+\lambda] < 0$ and $D(k) = (k-1)^2(1+\lambda)^2(2k+\lambda) > 0$, there exists a unique $n_d$, $n_d > k$, such that $D(n_d) = 0$. If $n \leq n_d$, $D(n) \geq 0$ and $\Delta g^D_I(n,k) \geq 0$ whereas if $n > n_d$, $D(n) < 0$ and $\Delta g^D_I(n,k) < 0$.

## Proof of Proposition 2.3

The proof follows directly from (2.17) since all the terms are positive when $k \geq 2$.

## Proof of Corollary 2.4

We have seen in the proof of Proposition 2.2 that the expression $\Delta g_I^D(n,k)$ is positive and then negative as $n$ increases. Clearly, $\lim_{n\to\infty} \Delta g_I^D(n,k) = 0$. Now we prove that this function is U-shaped in $n$, that is, it has a single minimum $n_m$. Take $\frac{\partial}{\partial n}\Delta g_I^D(n,k) = -\left[\frac{(1+\lambda)^2(2k+\lambda)(k+\lambda)}{S^3} - \frac{2+\lambda}{(1+\lambda+n)^3}\right](a-\overline{\theta})^2$. This function has the same zeros as $P(n) = (2+\lambda)S(n,k)^3 - (1+\lambda)^2(2k+\lambda)(k+\lambda)(1+\lambda+n)^3$. Since $P'''(n) = 6(k-1)(k+\lambda)[(2+\lambda)k+\lambda] > 0$ for all $n$ and $P''(k) = 6(k-1)(1+\lambda)(k+\lambda)(2k+\lambda) > 0$, then $P''(n)$ is positive for all $n$ and hence $P(n)$ is convex. Finally since rewriting we get that $P(k) = -(k-1)(1+\lambda)^2(2k+\lambda)[\lambda^2(2k-1)+\lambda(4k^2+k-1)+k(k^2+4k-1)] < 0$ and $\lim_{n\to\infty} P(n) = \infty$, there exists a unique $n_m$ such that $P(n_m) = 0$ and therefore $\frac{\partial}{\partial n}\Delta g_I^D(n_m,k) = 0$. If $n < n_m$, $P(n) < 0$ and $\frac{\partial}{\partial n}\Delta g_I^D(n,k) < 0$ whereas if $n \geq n_m$, $P(n) \geq 0$ and $\frac{\partial}{\partial n}\Delta g_I^D(n,k) \geq 0$. Obviously, $\Delta g_I^D(n_m,k) < 0$.

Therefore, on the one hand the deterministic curve $\Delta g_I^D(n,k)$ is U-shaped with $\Delta g_I^D(k,k) > 0$ and $\lim_{n\to\infty} \Delta g_I^D(n,k) = 0$. On the other hand since, from (2.17), $\Delta g_I^U$ is positive, independent of $n$ and increasing in $\sigma_\theta^2$, the deterministic curve is shifted up as the uncertainty increases and we have the conclusions of the text.

## Proof of Proposition 2.5

The profits of each outsider are $E(\pi_O) \equiv g_O^D + g_O^U$, where

$$g_O^D(n,k) = \frac{(k+\lambda)^2(2+\lambda)}{2S(n,k)^2}(a-\overline{\theta})^2, \tag{2.18}$$

and

$$g_O^U(n,k) = \frac{1}{2(2+\lambda)}\sigma_\theta^2. \tag{2.19}$$

Subtracting the expected profits when the merger does not take place (see proof of Lemma 2.1), we get that $\Delta E(\pi_O) = \Delta g_O^D$ and

$$\Delta g_O^D = \frac{(2+\lambda)}{2}\left[\frac{(k+\lambda)^2}{S^2} - \frac{1}{(n+\lambda+1)^2}\right](a-\overline{\theta})^2.$$

The previous expression has the same zeros in $n$ as $F(n) = (k+\lambda)^2(n+\lambda+1)^2 - S(n,k)^2$. Since $F(n)$ is a linear function with $F'(n) = 2k(k-1)(k+\lambda) > 0$ for all $n$ and $F(k) = k(k-1)[k^2 + k(3+4\lambda) + 2\lambda(1+\lambda)] > 0$, $F(n) > 0$ and therefore $\Delta g_O^D(n,k) > 0$ for all $n \geq k$.

## Proof of Proposition 2.7

Consider, firstly, the case in which $k$ insiders merge into a single firm. Substituting (2.4) and (2.5) in (2.8) we get that

$$w_M^D(n,k) = \frac{1}{2\lambda S(n,k)^2}\left[\sum_{r=0}^{2} \upsilon_r(k)(n-k)^r\right](a-\overline{\theta})^2,$$

where $\upsilon_0(k) = k(1+\lambda)^2(3k+\lambda)$,$\upsilon_1(k) = (k+\lambda)[\lambda^2+\lambda(3k+2)+4k]$ and $\upsilon_2(k) = (k+\lambda)^2$.

Next, the expected welfare in the equivalent deterministic environment if the firms decide not to merge is $w_N^D(n) = w_M^D(n,1)$. Hence,

$$\Delta w^D(n,k) = \frac{1}{2\lambda}\left[\frac{\sum_{r=0}^{2} \upsilon_r(k)(n-k)^r}{S^2} - \frac{n(n+\lambda+2)}{(n+\lambda+1)^2}\right](a-\overline{\theta})^2.$$

This expression is negative whenever $G(n) = (n+\lambda+1)^2\sum_{r=0}^{2}\upsilon_r(k)(n-k)^r - n(n+\lambda+2)S(n,k)^2$ is negative. We have that $G(n)$ is a quadratic polynomial function and $G''(n) = -2k\lambda(k-1)^2 < 0$. Since $G'(k) = -k^2(k-1)[2\lambda^2+\lambda(k+3)+2] < 0$ and $G(k) = -k(k-1)(1+\lambda)^2[k^2+(3+\lambda)k+\lambda] < 0$, it follows that $G(n)$ and, consequently, $\Delta w^D(n,k)$ are negative for all $n \geq k$.

## Proof of Proposition 2.8

The expected social welfare derived from the uncertainty if the merger goes ahead, substituting (2.4) and (2.5) in (2.9), is given by

$$w_M^U(n,k) = \left[\frac{(\lambda+3)n}{2(\lambda+2)^2} + \frac{2k(k-1)(4k+k\lambda+\lambda)}{\lambda(\lambda+2)^2(2k+\lambda)^2}\right]\sigma_\theta^2.$$

If the firms decide not to merge we have that $w_N^U(n) = w_M^U(n,1)$ and therefore

$$\Delta w^U = \frac{2k(k-1)(4k+k\lambda+\lambda)}{\lambda(\lambda+2)^2(2k+\lambda)^2}\sigma_\theta^2.$$

Clearly this function is always positive when $k \geq 2$.

## Proof of Corollary 2.9

We have seen in the proof of Proposition 2.7 that $\Delta w^D(n,k) < 0$. We also have that $\lim_{n\to\infty} \Delta w^D(n,k) = 0$. Through tedious but straightforward algebra, we can show that $\frac{\partial}{\partial n}\Delta w^D > 0$ for all $n \geq k$.[23] Since $\Delta w^U$ is always positive, independent of $n$ and increasing in $\sigma_\theta^2$, we have the conclusions in the text.

## Proof of Proposition 2.11

If a merger has been produced in the first stage, then, defining $\widetilde{\theta} = \frac{1}{n}\sum_{i=1}^n \theta_i$, the production of each of the insiders will be

$$x_i(\theta_1,\ldots,\theta_n) = r_I^{D,F}\,(a-\widetilde{\theta}) - r_{I,O}^{U,F}(\theta_i - \widetilde{\theta}) + r_{I,P}^{U,F}\sum_{p=1,p\neq i}^{k}(\theta_p - \widetilde{\theta}), \tag{2.20}$$

where $r_I^{D,F} = r_I^D$, $r_{I,O}^{U,F} = \frac{(\lambda+k-1)S+\lambda(k-1)}{\lambda(k+\lambda)S}$, $r_{I,P}^{U,F} = \frac{S-\lambda(k-1)}{\lambda(2+\lambda)S}$ and those of the outsiders

$$x_o(\theta_1,\ldots,\theta_n) = r_O^{D,F}(a-\widetilde{\theta}) - r_{O,O}^{U,F}(\theta_o - \widetilde{\theta}) + r_{O,P}^{U,F}\sum_{p=k+1,p\neq o}^{n}(\theta_p - \widetilde{\theta}), \tag{2.21}$$

where $r_O^{D,F} = r_O^D$, $r_{O,O}^{U,F} = \frac{S-(k-1)}{(1+\lambda)S}$, $r_{O,P}^{U,F} = \frac{k-1}{(1+\lambda)S}$. Substituting $k=1$, the case in which no merger has been produced in the first stage is obtained. The expected productions, when the merger has been produced as well as when it has not, are the same as in the private information case.

It is again possible to break expected profits up in two parts, $E(\pi^F) = g^{D,F} + g^{U,F}$. On the one hand, since the expected production is the same, the first term will be the same as in the private information case, $g^{D,F} = g^D$. On the other hand, proceeding in the same way as in the private information case we can obtain the expected profits derived from the uncertainty for the insiders. Substituting (2.20) and (2.21),

$$g_I^{U,F}(n,k) = \frac{1}{2\lambda S^2}\left[\sum_{r=0}^{2}\varphi_r(k)(n-k)^r\right]\sigma_\theta^2,$$

[23] We complete the missing steps and provide the expressions that have been left out in a technical Appendix, available at http://pareto.uab.es/wp/2002/54402_appendix.pdf.

where $\varphi_0(k) = (1+\lambda)^2(2k+\lambda)[2(k-1)+\lambda]$, $\varphi_1(k) = (2k+\lambda)[2(k-1)(1+\lambda)+\lambda(2\lambda+3)]$ and $\varphi_2(k) = (k-1)(k+\lambda) + \lambda(k+1+\lambda)$. Computing, we get that

$$g_I^{U,F}(n,k) - g_I^U(n,k) = \frac{1}{2(2k+\lambda)S^2}\left[\sum_{r=1}^{2}\phi_r(k)(n-k)^r\right]\sigma_\theta^2, \tag{2.22}$$

where $\phi_1(k) = (2k+\lambda)(2(k+1)+3\lambda)$, $\phi_2(k) = 3k+2\lambda$. Clearly this difference is positive. Therefore the profits derived from uncertainty are greater for the insiders and for the non-merging firms (taking $k=1$).

We have that $\Delta g_I^U - \Delta g_I^{U,F} = (g_N^{U,F} - g_N^U) - (g_I^{U,F} - g_I^U)$. From (2.22), this expression is positive whenever $J(n) = (2k+\lambda)S(n,k)^2\sum_{r=1}^{2}\phi_r(1)(n-1)^r - (2+\lambda)S(n,1)^2\sum_{r=1}^{2}\phi_r(k)(n-k)^r$ is positive. Following a similar procedure as before, we have that $J(n)$ is a polynomial function of degree four with $J^{iv}(n) > 0$ for all $n$ , $J'''(k) > 0$, $J''(k) > 0$, $J'(k) > 0$ and $J(k) > 0$. Therefore $J(n) > 0$ and consequently $\Delta g_I^U - \Delta g_I^{U,F} > 0$.

## Proof of Proposition 2.13

It is also possible to decompose $E(W^F) = w^{D,F} + w^{U,F}$. Similar to before, $w^{D,F} = w^D$ and

$$w_M^{U,F}(n,k) = \frac{1}{2\lambda(1+\lambda)^2S^2}\left[\sum_{r=0}^{3}\eta_r(k)(n-k)^r\right]\sigma_\theta^2,$$

where $\eta_0(k) = k(1+\lambda)^4[4k^2+4(-1+\lambda)k+(-1+\lambda)\lambda]$, $\eta_1(k) = (1+\lambda)[4(1+\lambda)^2k^3 + (10\lambda^3+19\lambda^2+\lambda-4)k^2+6\lambda^3(\lambda+2)k+(\lambda^2+2\lambda-1)\lambda^3]$, $\eta_2(k) = (1+\lambda)^2k^3+(6\lambda^3+14\lambda^2+6\lambda-1)k^2+\lambda^2(7\lambda^2+18\lambda+9)k+(2\lambda^2+5\lambda+2)\lambda^3$ and $\eta_3(k) = \lambda(2+\lambda)(k+\lambda)^2$. Repeating the same process as in Proposition 2.11, we can prove that $\Delta w^U - \Delta w^{U,F} \geq 0$.

## Proof of Proposition 2.14

The output of a firm that belongs to the coalition is given by

$$x_i(\theta_1,\ldots,\theta_k) = r_C^D(a-\overline{\theta}) - r_C^{U,O}(\theta_i - \overline{\theta}) + r_C^{U,P}\sum_{p=1,p\neq i}^{k}(\theta_p - \overline{\theta}), \tag{2.23}$$

where $r_C^D = r_N^D$, $r_C^{U,O} = \frac{k+\lambda}{(1+\lambda)(1+\lambda+k)}$ and $r_C^{U,P} = \frac{1}{(1+\lambda)(1+\lambda+k)}$, whereas the outsiders produce following the same rule as in the case where no merger or no coalition has been formed.

The expected profits of a coalition member is given by $E(\pi_C) = g_C^D + g_C^U$. The deterministic part is independent of the formation of the coalition and it is the same as when no merger had been formed in the first stage, $g_C^D = g_N^D$. The second part is, substituting (2.23),

$$g_C^U(n,k) = \frac{(2+\lambda)[(k-1)+(k+\lambda)^2]}{2(1+\lambda)^2(k+\lambda+1)^2}\,\sigma_\theta^2.$$

Of course, $g_C^U(n,1) = g_N^U(n)$ and $g_C^U(n,n) = g_N^{U,F}(n)$. Computing we get that,

$$\Delta g_C^U(n,k) = \frac{(k-1)[3\lambda^2+(8+2k)\lambda+3k+5]}{2(2+\lambda)(1+\lambda)^2(k+\lambda+1)^2}\,\sigma_\theta^2 \geq 0. \tag{2.24}$$

We only need to prove that the gains derived from the uncertainty are larger when firms merge than when they form a coalition. From (2.17) and (2.24),

$$\Delta g_I^U - \Delta g_C^U = \frac{(k-1)[\lambda^3+6\lambda^2+(5k+7)\lambda+2(k+1)^2]}{2\lambda(2k+\lambda)(1+\lambda)^2(k+\lambda+1)^2}\,\sigma_\theta^2 \geq 0.$$

## Proof of Lemma 2.16

Firms solve $Max_{x_j} E(\Pi_j|s_j)$, or substituting,

$$Max_{x_j}\left(a-\overline{\theta}-x_j-\sum_{l=1,l\neq j}^{n} E(x_l|s_j)\right)x_j-\left(E(\theta_j-\overline{\theta}|s_j)+\frac{\lambda}{2}x_j\right)x_j. \tag{2.25}$$

From the first order conditions, we posit that this problem has a linear symmetric equilibrium, $x_j = \overline{x} - r_N^U(s_j-\overline{\theta})$ and solve for $r_N^U$. This equilibrium is unique (see the approach in Section 8.1 in Vives, 1999).

## Proof of Lemma 2.17

The merged firm solves $Max_{x_1,\ldots,x_k} E(\Pi_M|s_1,\ldots,s_k)$ or substituting,

$$Max_{x_1,\ldots,x_k}\left(a-\overline{\theta}-\sum_{i=1}^{k}x_i-\sum_{l=k+1}^{n}E(x_l|s_1,\ldots,s_k)\right)\sum_{i=1}^{k}x_i-$$
$$\sum_{i=1}^{k}\left(E(\theta_i-\overline{\theta}|s_1,\ldots,s_k)+\frac{\lambda}{2}x_i\right)x_i.$$

The outsiders solve $Max_{x_o}E(\Pi_o|s_o)$, the analogous expression of (2.25). Similar to the previous proof, we posit a linear equilibrium and solve for $r_I^{U,O}$, $r_I^{U,P}$ and $r_O^U$. Again this equilibrium is unique.

## Proof of Proposition 2.20

We need to show that whenever $\Delta g_I^U(n,k,t)$ is negative then $\Delta g_I^D(n,k)$ is also negative. The gains derived from the uncertainty when $\lambda = 0$, substituting the corresponding output choices of Lemma 2.16 and Lemma 2.17 in the expected profits derived in Section 2.3.1,

$$\Delta g_I^U(n,k,t) = \left[\frac{tk^2(2-t)^2[1+t(k-1)]}{V(n,k,1,t)^2} - \frac{t}{[2+t(n-1)]^2}\right]\sigma_\theta^2.$$

Since when $t = 0$ the proof is straightforward, we assume in what follows that $t > 0$. This function is positive whenever $L(n,t) = k^2(2-t)^2[1+t(k-1)][2+t(n-1)]^2 - V(n,k,1,t)^2$ is positive. $L(n,t)$ is a quadratic polynomial function in $n$, $\frac{\partial^2 L(n,t)}{\partial^2 n} < 0$ and $L(k,t) > 0$ for all $n$ and $t$. Hence, for any $t^*$ there exists $n^*$ ($n^* > k$) such that $L(n^*,t^*) = 0$ and $\frac{\partial L(n^*,t^*)}{\partial n} < 0$. If we prove that $\frac{\partial L(n^*,t^*)}{\partial t} < 0$, by the implicit function theorem we have that $\frac{\partial n^*(t^*)}{\partial t} < 0$ and therefore $n^*(t^*) \geq n^*(1)$ for any $t^*$ ($\in (0,1]$). Going back to the initial function we have that if $\Delta g_I^U(n,k,t) < 0$ (i.e. $n > n^*(t)$) then $\Delta g_I^U(n,k,1) < 0$ (because $n > n^*(t) > n^*(1)$). However, computing we have that $\Delta g_I^U(n,k,1) < 0$ if and only if $\Delta g_I^D(n,k) < 0$. Therefore if $\Delta g_I^U(n,k,t)$ is negative then $\Delta g_I^D(n,k)$ is also negative.

Thus, we only need to show that $\frac{\partial L(n^*,t^*)}{\partial t} < 0$. We know that for a given $n^*$ there exists at least one $t^*(\in (0,1])$ such that $L(n^*,t^*) = 0$. If we show that it is unique, then since $L(n,0) = 0$, $\frac{\partial L(n,0)}{\partial t} = 0$ and $\frac{\partial^2 L(n,0)}{\partial^2 t} > 0$ for all $n$ and in particular for $n^*$, we have that $\frac{\partial L(n^*,t^*)}{\partial t} < 0$.

Define $M(n,t) = \frac{\partial^2 L(n,t)}{\partial^2 t}$. Since it is a polynomial function of degree 3 in $t$ and $M(n,0) > 0$ and $M(n,1) < 0$, it can only have one or three zeros in $t$ between 0 and 1. But since $\frac{\partial^3 M(n,t)}{\partial^3 t} > 0$ and $\frac{\partial^2 M(n,0)}{\partial^2 t} < 0$, $M(n,t)$ is concave and may be convex as $t$ increases. Therefore, since $M(n,0) > 0$, $M(n,t)$ has no more than two zeros in $t$ and thus it should have only one. Hence $\frac{\partial^2 L(n,t)}{\partial^2 t}$ is positive firstly and then negative as $t$ increases. In consequence, $L(n,t)$ is first convex and concave after. This, together with $L(n,0) = 0$ and $\frac{\partial L(n,0)}{\partial t} = 0$, proves that $L(n,t)$ can have only one zero in $t$ ($\in (0,1]$)for a given $n$.

# Appendix to Chapter 3

## Proof of Proposition 3.1

All but the main shareholder should receive the same ownership, $\tau_j = \frac{1-\tau_l}{k-1}$ for all $j \neq l$, reducing as much as possible $\Sigma\tau_t^2$ without affecting production decisions. Therefore we will have that $\Sigma\tau_t^2 = \tau_l^2 + (k-1)\frac{(1-\tau_l)^2}{(k-1)^2} = \frac{k\tau_l^2 - 2\tau_l + 1}{k-1}$. Substituting (3.3) and (3.4) into (3.7) we have that

$$U^*(\tau) = \frac{a^2[S-d(n-k)]^2[P + R\sigma^2(1+\rho(k-1))\frac{(1-\tau)(k\tau-1)}{k-1}]}{2[SP-d^2(n-k)k]^2}$$

and

$$\frac{\partial U^*(\tau)}{\partial \tau} = \frac{a^2[S-d(n-k)]^2 R\sigma^2(1+\rho(k-1))B(\tau)}{2[SP-d^2(n-k)k]^3}$$

where

$$B(\tau) = \frac{2k(1-\tau)}{k-1}[SP-d^2(n-k)k] - 2S(P+R\sigma^2(1+\rho(k-1))\frac{(1-\tau)(k\tau-1)}{k-1}.$$

Since $B(\frac{1}{k}) < 0$ and $B'(\tau) < 0$ for $\tau \in [\frac{1}{k}, 1]$, we have that $\frac{\partial U^*(\tau)}{\partial \tau} < 0$ and the optimal sharing rule is a merger of equals or $\tau^* = \frac{1}{k}$.

## Proof of Proposition 3.2

Substituting $\tau^* = \frac{1}{k}$ the difference in profits is given by

$$\frac{a^2[S-d(n-k)]^2 P}{2[SP-d^2(n-k)k]^2} - \frac{a^2[S+(n-k-1)d]}{2[S+kd]^2}.$$

Denote for simplicity $R \equiv R\sigma^2$. The merger is profitable whenever $F(R,n) = [S-d(n-k)]^2 P[S+kd]^2 - [S+(n-k-1)d][SP-d^2(n-k)k]^2$ is positive. This is a quadratic function in $n$ with $F(R,k) > 0$. We have that if $G(R) = \frac{\partial^2 F(R,0)}{\partial n^2} = \frac{d^2(k-1)(R^3+2d(k^2+1)R^2+d^2k(k^2-3k+1)R-2d^3k^3)}{k^2} > 0$ then $F(R,n)$ is positive for any $n$. Clearly we have that $G(0) < 0$ but $G''(R) > 0$ for all $R$. Defining $R^*$ such that $G(R^*) = 0$, we have that if $R \geq R^*$ then any merger is profitable (for any $n$).

Assume now that $R < R^*$. Then for any $R$ there exists $n^*(R)$ such that the merger is profitable whenever $n < n^*(R)$. We just need to show that for $R < R^*$

we have that $\frac{\partial n^*(R)}{\partial R} > 0$. By the implicit function theorem, $\frac{\partial n^*(R)}{\partial R} = -\frac{\frac{\partial F(R,n^*(R))}{\partial R}}{\frac{\partial F(R,n^*(R))}{\partial n}}$.The denominator should be positive since $F(R,k) > 0$ and $G(R) = \frac{\partial^2 F(R,0)}{\partial n^2} < 0$. Tedious but straightforward algebra shows that $\frac{\partial F(R,n^*(R))}{\partial R} < 0$.

## Proof of Proposition 3.3

A merger is welfare enhancing whenever $H(R,n) > 0$ where

$$\begin{aligned} H(R,n) &= k\{[S-d(n-k)]^2P[S+kd]^2 - [S+(n-k-1)d][SP-d^2(n-k)k]^2\} + \\ &(n-k)\{[P-kd]^2[S-(n-k-1)d][S+kd]^2 - [S+(n-k-1)d][SP-d^2(n-k)k]^2\} \\ &+ d\{[k[S-(n-k)d] + (n-k)[P-kd]]^2[S+kd]^2 - [SP-d^2(n-k)k]^2\}. \end{aligned}$$

Take $R$ such that there exists $n^{**}$ such that $H(R,n^{**}(R)) = 0$. If we show that $\frac{\partial H(R,n^{**}(R))}{\partial R} > 0$ then by the implicit function theorem we have that $sign(\frac{\partial n^{**}(R)}{\partial R}) = -sign(\frac{\partial H(R,n^{**}(R))}{\partial n})$. Then, we have that the region where the mergers are welfare enhancing is increased. On the one hand, if $\frac{\partial H(R,n^{**}(R))}{\partial n} < 0$ then the region where $n < n^{**}(R)$ (mergers are positive) is larger when we increase $R$ since $\frac{\partial n^{**}(R)}{\partial R} > 0$. On the other hand if $\frac{\partial H(R,n^{**}(R))}{\partial n} > 0$ then the region where $n > n^{**}(R)$ (mergers are positive) is larger when we increase $R$ since $\frac{\partial n^{**}(R)}{\partial R} < 0$.

We now need to show that $\frac{\partial H(R,n^{**}(R))}{\partial R} > 0$. Since $H(R,n)$ is a polynomial function of degree 5 in $R$ with $\frac{\partial^5 H(R,n)}{\partial R^5} > 0$, $\frac{\partial^4 H(0,n)}{\partial R^4} > 0$, $\frac{\partial^3 H(0,n)}{\partial R^3} > 0$, we have that $H(R,n)$ may be first concave but it is for sure later convex. Moreover, since $\frac{\partial H(0,n)}{\partial R} < 0$ and $H(0,n) < 0$ for all $n$ and $R$, we have that $H(R,n)$ has for a given $n^{**}$ a unique $R$ such that $H(R,n^{**}) = 0$ and $\frac{\partial H(R,n^{**})}{\partial R} > 0$.

From the last paragraph, since $H(0,n) < 0$ for all $n$ any merger reduces welfare when firms are risk neutral. Also for any possibility of merger in any industry structure, there is $R^{\hat{}}$ such that if $R > R^{\hat{}}$, the merger is welfare enhancing.

## Proof of Proposition 3.4

Define the utility of each insider as $U^*(\tau,k,\beta,\gamma,R\sigma^2,\rho)$. We need to show that $U^*(\frac{1}{k},k,\beta,\gamma,R\sigma^2,0) - U^*(1,1,\beta,\gamma,R\sigma^2,0) > 0$. Since the optimal sharing rule is the equal one, we have that $U^*(\frac{1}{k},k,\beta,\gamma,R\sigma^2,0) > U^*(1,k,\beta,\gamma,R\sigma^2,0)$. By the definition of $S$ and $P$ we have that $U^*(1,k,\beta,\gamma,R\sigma^2,0) = U^*(1,k,\widehat{\beta},\gamma,0,0)$ where $\widehat{\beta} = \beta + \frac{R}{2}\sigma^2$. Then, as shown by Davidson and Deneckere (1985) we have that

$U^*(1,k,\widehat{\beta},\gamma,0,0) - U^*(1,1,\widehat{\beta},\gamma,0,0) > 0$. Then, we have shown $U^*(\frac{1}{k},k,\beta,\gamma,R\sigma^2,0) - U^*(1,1,\beta,\gamma,R\sigma^2,0) > U^*(1,k,\beta,\gamma,R\sigma^2,0) - U^*(1,1,\beta,\gamma,R\sigma^2,0) > 0$.

## Proof of Proposition 3.5

All but the main shareholder should receive the same ownership, $\tau_j = \frac{1-\tau_l}{k-1}$ for all $j \neq l$, reducing as much as possible $\Sigma\tau_t^2$ without affecting production decisions. Therefore we will have that $\Sigma\tau_t^2 = \tau_l^2 + (k-1)\frac{(1-\tau_l)^2}{(k-1)^2} = \frac{k\tau_l^2 - 2\tau_l + 1}{k-1}$. Substituting (3.10) and (3.11) into (3.7) we have that

$$U^*(\tau) = \frac{\alpha^2[\beta + (\beta+\gamma)(1+\beta R\sigma^2)](\beta-(k-1)\gamma)C(\tau)}{2(M(1+\tau L)+N)^2}$$

where

$$C = 2 + R\sigma^2(1+\rho(k-1))(\beta-(k-1)\gamma)\frac{-k\tau^2+2k\tau-1}{k-1}.$$

Then $\frac{\partial U^*(\tau^*)}{\partial\tau} = 0$ where

$$\tau^* = \frac{M\left(1+\frac{1}{k}L - \frac{2(k-1)}{k}\right)+N}{M(1+L)+N}.$$

We have that $\tau^* > \frac{1}{k}$ and $\tau^* < 1$.

## Proof of Proposition 3.7

Define $D(R\sigma^2) = R\sigma^2[1-\tau^*(R\sigma^2)]$. Tedious computations lead to $D'(R\sigma^2) > 0$, $D(0) = 0$ and $\lim_{R\sigma^2\to\infty} D(R\sigma^2) = +\infty$. Therefore there exists a unique $\widehat{R\sigma^2}$ such that $D(\widehat{R\sigma^2}) = \widehat{R\sigma^2}[1-\tau^*(\widehat{R\sigma^2})] = \frac{\gamma(k-1)}{\beta[\beta-\gamma(k-1)]}$. If $R\sigma^2 < \widehat{R\sigma^2}$ then $D(R\sigma^2) < 0$ whereas if $R\sigma^2 > \widehat{R\sigma^2}$ then $D(R\sigma^2) > 0$.

## Proof of Proposition 3.6

The utility of each insider is given again by $U^*(\tau^*,k,R\sigma^2,c)$. We need to show that $U^*(\tau^*,k,R\sigma^2,0) - U^*(1,1,R\sigma^2,0) > 0$. Since the optimal sharing rule gives higher utility than the "takeover", we have that $U^*(\tau^*,k,R\sigma^2,0) > U^*(1,k,R\sigma^2,0)$.

Now define the profits of an insider in an environment without uncertainty as $\widehat{U}(n,k,\beta,\gamma,c)$ where $n,k,\beta,\gamma$ are defined as in our model and $c$ are the constant marginal costs of production. Again by Davidson and Deneckere (1985) we have that $\widehat{U}(n,k,\beta,\gamma,c) - \widehat{U}(n,1,\beta,\gamma,c)$. By definition of the utility function we have that $U^*(1,k,R\sigma^2,0) = \widehat{U}(n,k,\beta,\gamma,\frac{R}{2}\sigma^2)$. Hence $U^*(\tau^*,k,R\sigma^2,0) - U^*(1,1,R\sigma^2,0) > U^*(1,k,R\sigma^2,0) - U^*(1,1,R\sigma^2,0) > 0$.

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