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Should Mergers be Controlled?

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Abstract

Anticompetitive mergers benefit competitors more than the merging firms. We show that such externalities reduce firms' incentives to merge (a holdup mechanism). Firms delay merger proposals, thereby foregoing valuable profits and hoping other firms will merge instead - a war of attrition. The final result, however, is an overly concentrated market. We also demonstrate a surprising intertemporal link: Merger incentives may be reduced by the prospect of additional profitable mergers in the future. Merger control may help protect competition. Holdup and intertemporal links make policy design more difficult, however. Even reasonable policies may be worse than not controlling mergers at all.

Key Words: endogenous mergers & acquisitions; coalition formation; competition policy

JEL classification: L41; L12; C78.

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1 Introduction

In 1999, the worldwide value of mergers and acquisitions exceeded 3.4 trillion US dollars (The Economist, 2000). While many of the transactions in this current wave are motivated by legitimate responses to changing business conditions such as global competition, deregulation, and over capacity, a larger share involves direct competitors than in the past (Pitofsky, 1997). Thus, this current wave revives the old controversy over the costs and benefits of merger control.

One of the alleged motives for mergers between competitors is increased market power and, as a result, markets might become too concentrated from a social welfare point of view. Stigler (1950) points out an important countervailing force, however. If market power is the main motive for a merger, remaining outside the merger is usually more profitable than participating. Firms may thus not have an incentive to participate in such mergers, even if they are profitable. This countervailing force, referred to as the holdup mechanism, has important implications for competition policy. It suggests that horizontal mergers are primarily formed for other reasons than market power, for instance cost synergies and other socially desirable goal, and that controlling mergers may thwart, or at least delay, such gains.

The oligopoly models studied by Szidarovszky and Yakowitz (1982), Salant, Switzer, and Reynolds (1983), Perry and Porter (1985), and Deneckere and Davidson (1985) support the idea that outsiders gain from a merger (positive externalities). In many cases, outsiders gain more than insiders do (strong positive externalities), since outsiders benefit from the price increase, but need not reduce output themselves. More recently, Kamien and Zang (1990 and 1993) studied a non-cooperative model of the acquisition process which exhibits a holdup mechanism. They show that positive externalities indeed prevent firms from agreeing to certain profitable mergers involving *three* firms or more. Consider a triopoly firm attempting to buy both competitors at the same time. By unilaterally rejecting the offer, each target becomes a duopolist. Therefore, both targets will require compensation for a duopoly profit and not only for the triopoly profit.

Like Kamien and Zang, we explicitly analyze the acquisition process as a non-cooperative coalition formation game.[1] We demonstrate that *strong* positive externalities reduce the incentives for *two* firms to merge, even if the merger is profitable. We also show that this holdup mechanism takes the form of delay, rather than completely preventing anti-competitive mergers. The intuition is that firms delay the merger proposals and consequently forego valuable profits, since there is a chance that other firms might merge instead–much like a war of attrition. The final result, however, is excessive concentration.

To describe the acquisition process, we construct an extensive form model of coalitional bargaining. In particular, we construct a so-called game of timing. Any firm can submit a merger proposal to any other firm(s) at any point in time. The recipient(s) of a proposal can either accept or reject it. In the latter case, the recipient can make a counterproposal in the future. As a consequence, firms endogenously decide whether and when to merge, and how to split the surplus while keeping alternative mergers in mind. There are two important differences between our analysis and the one by Kamien and Zang. First, they cannot predict how merging firms split their surplus. Second, by

[1] The idea to use the theory of coalition formation for studying mergers originates with Stigler (1950). The first formal work was made by Salant, Switzer, and Reynolds (1983, section IV), Mackay (1984) and Deneckere and Davidson (1985b). Two more recent contributions include Gowrisankaran (1999) who uses simulation techniques to analyze endogenous mergers in a context where entry, exit, and internal expansion are allowed, and Horn and Persson (2000a, 2000b) who analyze endogenous mergers when firms differ, by using a cooperative approach.

focusing on asymmetric equilibria, Kamien and Zang in effect exogenously assign specific roles to the firms, that is, they choose which firms are buyers, sellers, and outsiders, respectively. This means that they overlook two important problems in the merger process. The market mechanism itself must split the surplus, and select the buyer when different roles yield different payoffs. In our model, these are the problems materializing as holdup mechanisms.

Since the holdup mechanism only creates temporary frictions to monopolization, merger control may play an important part for preserving competitive markets. To design merger control properly, the holdup mechanism must be taken into account. Consider the current use of divestiture as a remedy for anti-competitive mergers. In the US, most cases are today resolved by consent decree, where the deal is allowed to close so long as a package of assets sufficiently large to address competitive concern is set aside for divestiture (Baer, 1996). Also in Europe, mergers are approved on condition that the merging firms divest part of their assets. For example, the merger in 1992 between Nestlé and Perrier involved the divestiture of Perrier's subsidiary Volvic to the competitor BSN (Compte, Jenny and Rey, 1996). We show that such divestiture requirements eliminate the holdup mechanism. Requiring divestiture introduces a channel for transferring wealth from competitors to the merging firms. As a result, the merging firms can appropriate the positive externalities and mergers are proposed immediately. If the competition authorities are well informed, eliminating the holdup mechanism increases welfare. Welfare increasing mergers are hastened, while welfare reducing mergers can still be blocked. In practice, however, competition authorities have limited information, and the divestiture policy is applied to mergers violating a more or less arbitrary threshold level of concentration. In such circumstances, the divestiture policy also hastens welfare deteriorating mergers.

We also demonstrate a surprising inter-temporal link. Merger incentives may be reduced by the prospect of additional profitable mergers in the future. The prospect of a future merger increases the value of becoming an insider in the first merger, which tends to hasten it. The prospect of a future merger may, however, increase the value of becoming an outsider in the first merger even more. If so, the first merger will be delayed by the prospect of the future merger. This intertemporal link between mergers creates additional problems for the appropriate design of merger control. We provide two examples indicating that, in some markets, reasonable merger policies are worse than not controlling mergers at all.

First, in some markets, a policy prohibiting mergers in concentrated market structures hastens mergers in less concentrated ones. By prohibiting mergers from duopoly to monopoly, the value of first merging from triopoly to duopoly is reduced, which tends to reduce the incentives for merging to duopoly. More interestingly, the value of becoming an outsider in the triopoly-to-duopoly merger is reduced even more. As a result, forbidding mergers to monopoly reduces the holdup friction in mergers to duopoly. In an industry where social welfare is higher the less concentrated is the market, forbidding mergers to monopoly is expected to be better than not controlling mergers at all. This need not be the case, however, due to the intertemporal link. On the one hand, forbidding merger to monopoly decreases the concentration in the final market structure (duopoly rather than monopoly) which is a welfare gain. On the other hand, the triopoly remains for a shorter period of time, which is a welfare cost.

Second, even the policy to allow a merger if, and only if, the merger increases social welfare is, in some cases, worse than not controlling mergers at all. The reason is that such a case-by-case policy does not take the intertemporal links between mergers into account. Consider an industry where monopoly is socially inferior to duopoly due to dead weight losses. Duopoly and monopoly are socially preferred to triolopy due to cost reductions in the merged firm as well as the outsider (technological spillovers). In such an industry, a merger from triopoly to duopoly may be unprofitable since the merging firms lose market shares. A merger from duopoly to monopoly is profitable, due to increased market power. Moreover, a merger from triopoly to duopoly would occur, if a subsequent merger to monopoly were to be approved, otherwise not. As a result, a laisser faire policy leads to monopoly while, in contrast, the case-by-case policy implies that no mergers are carried out. Consequently, the triopoly persists, even though it is the least advantageous outcome from a welfare point of view. Unfortunately, taking the intertemporal link into account is difficult. That would require much more information than the case-by-case policy. Moreover, there is a commitment problem. Once a merger from triopoly to duopoly has occurred, it is actually optimal to block the merger to monopoly.

2 The Model

Time is infinite and continuous but divided into short periods of length Δ. Each period is divided into two phases. In the first phase, there is an acquisition game where all firms can simultaneously submit bids for other firms. A firm receiving a bid can only accept or reject it; if rejecting, it can give a (counter) offer at the beginning of the next period. We assume that no time elapses during the acquisition game, although it is described as a sequential game. We also make an auxiliary assumption about the bargaining technology. If more than one firm bids at the same time, only one bid is transmitted, all with equal probability.[2]

In the second phase, there is a market game. Rather than specifying an explicit oligopoly model, the profit levels of each firm in each market structure are taken as exogenous variables. To focus on the mechanisms we want to illustrate, we only consider an industry with three identical firms, each firm earning the profit flow $\pi(3)$. If a merger from triopoly to duopoly takes place, the merged firm earns profit flow $\pi(2^+)$, and the outsider earns $\pi(2^-)$. If a merger to monopoly occurs, the remaining firm earns profit flow $\pi(1)$.

Our analysis shows how merger incentives (the acquisition phase) depend on profit flows in the different market structures (the market phase). We make frequent use of Figure 1, which summarizes all possible profit flow configurations connected with mergers from triopoly to duopoly (when mergers to monopoly cannot take place). The effects of mergers on insiders' and outsiders' profit flows have been studied by the exogenous merger literature.[3] According to this literature, a merger may be profitable, in the sense that $\pi(2^+) > 2\pi(3)$, for example due to increased market power or efficiency gains. In Figure 1, this possibility is illustrated as the area above the line labeled $I_{32} = 0$. However, a merger may also be unprofitable if, for example,

[2] This is a simple and transparent way of circumventing an already well-known problem. Under certain conditions, the bargaining game behaves as a so-called preemption game. If all players decide to move simultaneously, technical difficulties may arise. In our model, the firms may agree on mutually inconsistent contracts. Other solutions to this problem are discussed by Fudenberg and Tirole (1991, pp. 126-8). The effect on our results of this assumption is discussed in Fridolfsson and Stennek (2000).

[3] This literature studies whether an exogenously selected group of firms (insiders) would increase their profit by merging compared to the situation in an unchanged market structure. Depending on the details of the situation the insiders (and the outsiders) would or would not profit from a merger, see Szidarovszky and Yakowitz (1982), Salant, Switzer and Reynolds (1983), Deneckere and Davidson (1985), Perry and Porter (1985), Levy and Reitzes (1992, 1995)

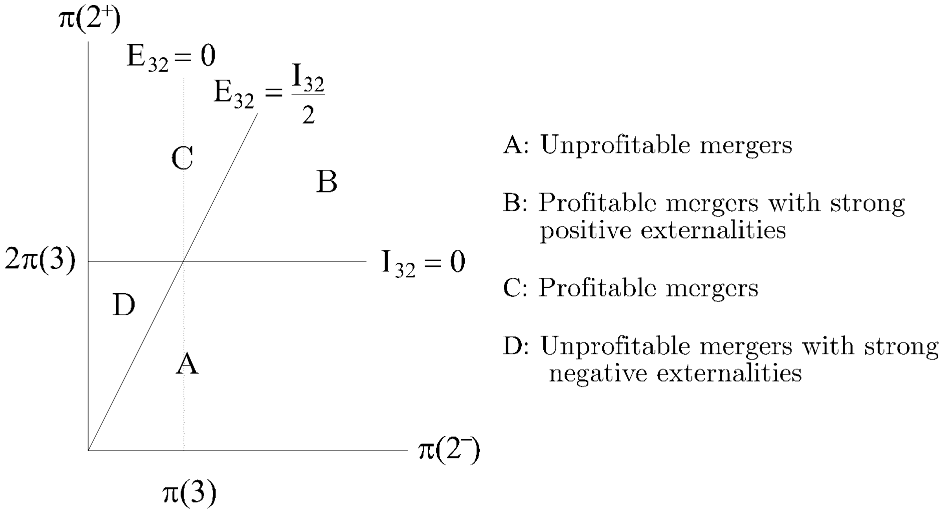

Figure 1: case when mergers to monopoly are illegal.

the outsider expands production substantially in response to the merger, if the new organization is more complex to manage, or if there are substantial restructuring costs. In Figure 1, this possibility is illustrated as the area below the $I_{32} = 0$ line. Normally, a merger also confers an externality on the outsider. Since a merger reduces the number of competitors, there is a positive market power effect, so that $\pi(2^-) > \pi(3)$. In Figure 1, this possibility is illustrated as the area to the right of the "zero-externality line," labeled $E_{32} = 0$. However, if the merging parties can reduce their marginal costs substantially, they become a more difficult competitor. This may harm outsiders, so that $\pi(2^-) < \pi(3)$. In Figure 1, this possibility is illustrated as the area to the left of the $E_{32} = 0$ line. Furthermore, in many cases, the externality is strong in the sense that the effect on the outsider's profit is larger than the effect on the insiders' profits, that is $|\pi(2^-) - \pi(3)| > \left|\frac{1}{2}\pi(2^+) - \pi(3)\right|$. Area D contains all markets where a merger is unprofitable, and even more unprofitable to the outsider. Area B contains all markets where a merger is profitable, but even more profitable to the outsider. In the following analysis, we show that the incentives to merge are very different depending on the area (A, B, C or D) in which the firms find themselves.[4]

Working backwards, we start by analyzing firms' incentives to merge from duopoly to monopoly. Since the acquisition game is the same as the one presented below (for the case of mergers from triopoly to duopoly) and the analysis is straightforward, we only present the result. Let the profitability of a merger from duopoly to monopoly be denoted by

$$I_{21} \equiv \left[\pi(1) - \pi\left(2^{+}\right) - \pi\left(2^{-}\right)\right]/r. \quad (1)$$

In equilibrium, the two firms do not merge if, and only if, $I_{21} \leq 0$; they merge immediately if, and only if, $I_{21} \geq 0$. The expected split of the surplus is equal, that is each firm receives $I_{21}/2$.

Next, we analyze firms' incentives to merge from triopoly to duopoly, taking into account the possibility of subsequent mergers to monopoly. (The case when firms can buy more than one firm at a time is discussed at the end of Section 3.) In the triopoly, a firm's strategy describes the firm's behavior in the acquisition game: whether the firm submits a bid to some other firm, the size of that bid, and a reservation price at which the firm accepts to sell, if receiving a bid from some other firm. It specifies the behavior for all points in time, and for all possible histories at that time.

Conforming to the fundamental idea of endogenous merger analysis, we restrict our attention to symmetric equilibria. If we were to study asymmetric equilibria, we would, in effect, exogenously assign a role (buyer, seller or outsider) to each firm. Hereby, we would neglect an important friction in the merger process, namely that the market itself must select the roles of

[4] All possible profit configurations can be generated by means of a simple oligopoly model (see Fridolfsson and Stennek, 2000).

different firms, when different roles yield different payoffs. We also restrict our attention to Markov strategies, which means that firms do not condition their behavior on time (stationarity) or on the outcome of previous periods (history independence).[5] A symmetric Markov perfect equilibrium is characterized by the triple (p, b, a), where $p \in [0, 1/2]$ denotes the probability of a firm bidding for one specific firm in a given period, b denotes the size of this bid, and a denotes the lowest bid a target will accept. For convenience, we only consider bids that would be accepted if submitted.

We now define the continuation values of the firms after a merger from triopoly to duopoly, at the date of merger and before merger. After a merger to duopoly has occurred, the values of the merged (+) firms and the outside (-) firm are given by

$$W\left(2^{i}\right) = \pi\left(2^{i}\right)/r + e^{-r\Delta} I_{21}^{*}/2, \tag{2}$$

for $i \in \{+, -\}$, where r is the common discount rate, $\pi\left(2^{i}\right)/r$ is the discounted value of all future profits in the duopoly, and $I_{21}^{*} \equiv max\left\{0, I_{21}\right\}$ is the additional value of the firms in the duopoly due to the opportunity to merge to monopoly in the next period. At the time a merger occurs, the values of the buying, selling, and outsider firms are given by

$$\begin{aligned} V^{buy} &= W\left(2^{+}\right) - b, & \text{(3a)} \\ V^{sell} &= b, & \text{(3b)} \\ V^{out} &= W\left(2^{-}\right), & \text{(3c)} \end{aligned}$$

[5] With non-Markov strategies, a plethora of outcomes can be supported in the models studied by Chatterjee, Dutta, Ray, and Senegupta (1993) and Ray and Vohra (1995). (The main difference between their approach and ours is that they exogenously specify the order of proposers in the bargaining game.) Such multiplicity is also likely to exists in our model. The Markov perfect equilibrium could be motivated by its simplicity, and the fact that it is easier to coordinate on (Maskin and Tirole, 1995).

respectively. In the triopoly, the expected value of any firm is given by

$$W(3) = \frac{1}{r}\pi(3)\left(1 - e^{-r\Delta}\right) + e^{-r\Delta}\left[2qV^{buy} + 2qV^{sell} + 2qV^{out} + (1 - 6q)W(3)\right]. \tag{4}$$

The first term, $\frac{1}{r}\pi(3)\left(1 - e^{-r\Delta}\right)$, is the value generated by the triopoly in the current period, the second term is the discounted expected value of all future profits. In particular, the value of being a buyer (seller, outsider, triopolist) in the next period, is multiplied by the probability of becoming a buyer (seller, outsider, triopolist) in that period. By definition, q denotes the probability of a specific firm buying another specific firm, and is given by[6]

$$q = \frac{1 - (1 - 2p)^3}{6}. \tag{5}$$

Let $EV(b)$ denote the expected value for firm i of bidding with certainty on firm j, and $EV(nb)$ the expected value for firm i of not bidding for any firm. To find expressions for $EV(b)$ and $EV(nb)$ that are easily interpreted, let there be n (=3) firms in the initial market structure, and let $m \in \{0, \ldots, n-1\}$ denote the number of *other* firms ($j \neq i$) submitting a bid at a given point in time. Note that m is a binomial random variable with parameters $(n-1)$ and $(n-1)p$. Then,

$$EV(b) = V^{buy}E\left\{\tfrac{1}{m+1}\right\} + V^{sell}E\left\{\tfrac{m}{m+1}\right\}\tfrac{1}{n-1} + V^{out}E\left\{\tfrac{m}{m+1}\right\}\tfrac{n-2}{n-1}. \tag{6}$$

The value of buying is multiplied with $E\{1/(m+1)\}$, since $1/(m+1)$ is the probability of firm i's bid being transmitted, when $m+1$ firms make a bid. The value of selling is multiplied with $E\{m/(m+1)\}/(n-1)$, since $m/(m+1)$ is the probability of i's bid not being transmitted, and $1/(n-1)$

[6] To see this, note that $q = (1 - q_0)/6$, where q_0 is the probability of remaining in status quo, and that $q_0 = (1 - 2p)^3$, which is the probability of no firm making a bid. The status quo only remains if no firms submit a bid, since all bids are designed to be accepted.

is the probability of i receiving the transmitted bid. Moreover,

$$EV(nb) = W(3)\Pr\{m=0\} + V^{out}\left[1-\Pr\{m=0\}\right]\tfrac{n-2}{n-1} + V^{sell}\left[1-\Pr\{m=0\}\right]\tfrac{1}{n-1}. \tag{7}$$

The value of remaining in status quo is multiplied with the probability that no other firm bids ($m = 0$), which is the only case where the tri-opoly ($n = 3$) persists. The value of being an outsider is multiplied with $\left[1-\Pr\{m=0\}\right]\left(\frac{n-2}{n-1}\right)$, that is, the probability that at least one firm bids, and the probability that this bid is not for i.

Three equilibrium conditions complete the model. First, by subgame perfection, an offer is accepted if, and only if, the bid is at least as high as the value of the firm, that is

$$a = W(3). \tag{8}$$

Second, for the bid to maximize the bidder's profit, it is necessary that

$$b = W(3). \tag{9}$$

The third equilibrium condition is that firms submit a bid if, and only if, this is profitable (recall that the probability of bidding for a specific other firm is restricted to $p \leq 1/2$ by the symmetry assumption):

$$\begin{cases} \text{Immediate merger:} & p=\frac{1}{2} & \text{and} & EV(b) \geq EV(nb) & \text{or} \\ \text{No merger:} & p=0 & \text{and} & EV(b) \leq EV(nb) & \text{or} \\ \text{Delayed merger:} & p\in(0,1/2) & \text{and} & EV(b) = EV(nb). & \end{cases} \tag{10}$$

To describe the equilibrium structure, we let the profitability of a merger from triopoly to duopoly, that is the internal effect, be denoted by

$$I_{32} \equiv \left[\pi\left(2^{+}\right) - 2\pi(3)\right]/r. \tag{11}$$

The gain from becoming an outsider, that is the externality, is denoted by

$$E_{32} \equiv \left[\pi\left(2^{-}\right) - \pi\left(3\right)\right]/r. \tag{12}$$

The profitability of a merger from triopoly to monopoly is denoted by

$$I_{31} \equiv \left[\pi\left(1\right) - 3\pi\left(3\right)\right]/r. \tag{13}$$

Throughout the paper, merger to monopoly is assumed to be profitable, that is, $I_{21}, I_{31} > 0$.

The incentives to merge from triopoly to duopoly are influenced by the possibility of a subsequent merger to monopoly. To take the intertemporal link into account, we define the average gain of becoming an insider as

$$I \equiv \left[I_{32} + I_{21}^{*}/2\right]/2, \tag{14}$$

and the gain of becoming an outsider as

$$E \equiv E_{32} + I_{21}^{*}/2. \tag{15}$$

Note that I is defined as an average gain (is divided by 2) while I_{32}, I_{21} and I_{31} are defined as total gains.

Lemma 1 *Consider mergers from triopoly to duopoly. Consider the set of symmetric Markov perfect equilibria as* $\Delta \to 0$*. A no-merger equilibrium exists if, and only if,* $I \leq 0$*. An immediate-merger equilibrium exists if, and only if,* $I \geq E$*. A delayed-merger equilibrium exists if, and only if,* $|E| > |I|$ *and* $sign\{E\} = sign\{I\}$*.*

All proofs are relegated to Appendix A. It is easy to demonstrate that an equilibrium exists for all possible parameter configurations. The implications of the equilibrium structure is discussed in the next section, focusing on delayed and no-merger equilibria.

The model also predicts when a delayed merger will occur. Note that there are t/Δ time periods between time 0 and time t. Hence, the triopoly remains until time t with probability $(q_0(\Delta))^{t/\Delta}$, where q_0 depends on the period length. Define the cumulative distribution function that indicates the probability of a merger not having occurred before time t, as

$$G_0(t) \equiv \lim_{\Delta \to 0} (q_0(\Delta))^{t/\Delta}.$$

Lemma 2 *In delayed merger equilibria, $G_0(t) = e^{-\Theta r t}$, where $\Theta \equiv 3I/(E-I) > 0$.*

The probability of a merger having occurred at time t is $G(t) = 1 - e^{-\Theta r t}$. Note that the probability of a merger having occurred at $t = 0$ is zero, and that the probability of a merger having occurred is one, when $t \to \infty$. The expected time before merger is $\int_0^\infty r\Theta e^{-\Theta r t} t dt = 1/(r\Theta)$.[7]

The model predicts how the surplus will be split. In particular, in a delayed merger equilibrium, the insiders split the surplus equally. As far as we know, no previous model of mergers has succeeded in predicting how the surplus will be split by merging firms.[8]

3 Holdup

By holdup we mean that a profitable merger does not occur or occurs with a delay. In this section, we present two distinct holdup mechanisms that are

[7] The probability of a merger taking place in the time interval $(t, t+dt)$, given that no merger has occurred before t, is constant and given by $g(t)dt/G_0(t) = r\Theta dt$, where $g(t) = r\Theta e^{-\Theta r t}$ is the merger density.

[8] Kamien and Zang (1990, 1991, 1993) cannot predict how the surplus will be split, since they construct their bargaining model as a Nash demand game. Firm F makes a bid b, and firm G simultaneously announces a reservation price a. If $b = a$, they have split the surplus in a consistent way, and the merger will be carried out, otherwise not. Hence, any split of the surplus is an equilibrium. Our model, on the other hand, is closer to the Rubinstein-Ståhl bargaining model.

immediate consequences of Lemma 1. For convenience, the first mechanism is presented in two separate propositions.

Consider the case when mergers from duopoly to monopoly are blocked by competition authorities (which is as if $I_{21}^{*}=0$). In this case, the equilibrium structure of Lemma 1 is described by Figure 1. There exists a no-merger equilibrium if, and only if, $I_{32}\leq 0$, that is, $\pi\left(2^{+}\right)\leq 2\pi\left(3\right)$, which is illustrated as areas A and D. There exists an immediate-merger equilibrium if, and only if, $I_{32}/2\geq E_{32}$, that is, $\pi\left(2^{+}\right)/2\geq\pi\left(2^{-}\right)$, which is illustrated as areas C and D. A delayed-merger equilibrium exists in areas B and D. Since mergers to duopoly are profitable in area B, this delay is a form of holdup.

Proposition 1 *Assume that mergers to monopoly are illegal. Consider a market where mergers from triopoly to duopoly are profitable, that is $I_{32}>0$, but it is better to be an outsider than an insider, that is $E_{32}>I_{32}/2$. A merger occurs with probability one in the long run. However, the expected waiting time is strictly positive, and equal to $1/\left[r\Theta\right]$ as $\Delta\rightarrow 0$.*

Proposition 1 is particularly relevant for anti-competitive mergers since, in these cases, it is better to be an outsider than an insider. The proposition shows that strong externalities counteract, but do not completely offset, the incentives for such mergers. The intuition is that firms delay their merger proposals, and consequently forego valuable profits, since other firms might merge instead. We see this as a formalization of Stigler's (1950) holdup mechanism. Despite the holdup mechanism, however, the final result is excessively concentrated markets.

Next, consider the case when mergers from duopoly to monopoly are allowed by the competition authorities. In this case, the equilibrium structure of Lemma 1 is illustrated in Figure 2. Note that if $I_{21}<0$, the duopoly would

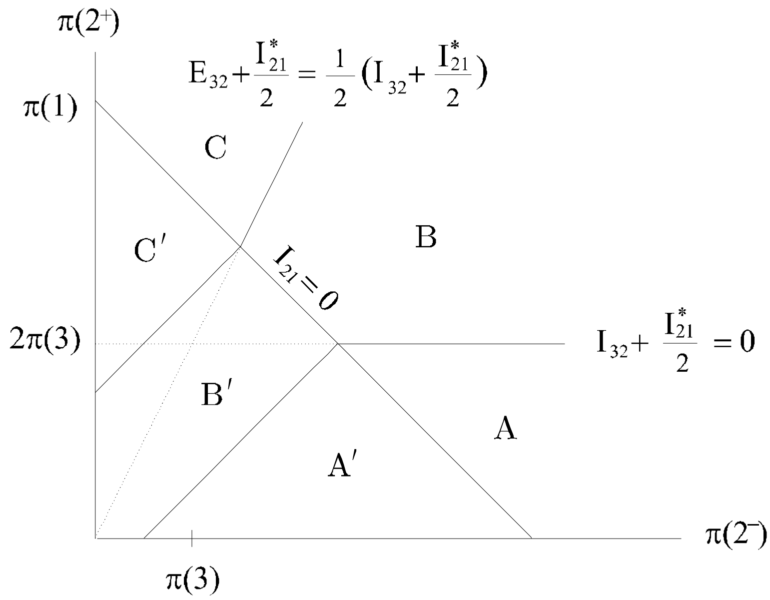

Figure 2: case $I_{31} > 0$.

be stable. This region lies to the north-east of Line $I_{21} = 0$ and is, in turn, partitioned into equilibrium-areas A, B and C, as in the case when mergers to monopoly were ruled out by assumption. Under our assumption that $I_{21} > 0$, the duopoly is unstable. This region lies to the south-west of Line $I_{21} = 0$. A no-merger equilibrium exists if, and only if, $I_{32} + I_{21}/2 \leq 0$. In terms of profit flows, the condition is $\pi(2^+) \leq [4\pi(3) - \pi(1)] + \pi(2^-)$, which is illustrated as area A'. An immediate-merger equilibrium exists if, and only if, $(I_{32} + I_{21}/2)/2 \geq E_{32} + I_{21}/2$. In terms of profit flows, the condition is $\pi(2^+) \geq \pi(1)/3 + \pi(2^-)$, which is illustrated as area C'. Similarly, a delayed merger equilibrium exists in area B'. Since the sequence of mergers from triopoly to monopoly is profitable, the delay in area B' is a form of holdup.

Proposition 2 *Consider a market where mergers from triopoly (and duopoly) to monopoly are profitable and where the gain from becoming an insider is* *positive, that is* $(I_{32} + I_{21}/2)/2 > 0$*, but the gain from becoming an outsider is even larger, that is* $E_{32} + I_{21}/2 > (I_{32} + I_{21}/2)/2$*. A merger from triopoly to monopoly (via duopoly) occurs with probability one in the long run. However, the expected waiting time is strictly positive, and equal to* $1/[r\Theta]$ *as* $\Delta \to 0$.

Propositions 1 and 2 constitute two examples of the same mechanism; the difference is that, in the latter case, it is the monopoly that is delayed.

When merger to monopoly is allowed, being an outsider (in the merger to duopoly) may be better than being an insider for two distinct reasons. One reason is that the merger from triopoly to duopoly is mainly motivated by market power, so that there is a strong positive externality, that is $E_{32} > I_{32}/2$. The other reason is that the outsider captures a larger share of the surplus in the subsequent merger to monopoly than do the insiders (per firm), that is $I_{21}/2 > I_{21}/4$.

The holdup mechanism described in Propositions 1 and 2 is a form of coordination failure in the acquisition game. All firms are better off by a merger compared to the original situation. The fundamental problem is that different roles (buyer, seller, outsider) give different payoffs. The holdup friction is the result of the firms' desire to become outsiders; in equilibrium, the firms delay their bids, hoping that other firms will merge instead.

Another way of seeing that it is indeed the allocation of roles that creates holdup, is to consider asymmetric equilibria where one firm is *exogenously* selected for each role. One firm is exogenously appointed to stay as an outsider and receive profit flow $\pi(2^-)$. The other firms are appointed as insiders and can share profit flow $\pi(2^+)$. Such asymmetric equilibria (only) exist in areas B and B' of Figures 1 and 2. Moreover, an asymmetric merger is achieved immediately. Thus, when the firms do not need to allocate roles, there is no holdup. However, in such an equilibrium the values of the different firms (in the triopoly) differ according to which role they have exogenously been assigned. Why, one may ask, are the insiders willing to accept their roles? Why does a buyer not delay a merger proposal, to see if the appointed outsider gives in, and makes an offer first?[9]

Kamien and Zang (1990, 1993) do not identify this holdup mechanism since they allocate roles exogenously. To be more precise, Kamien and Zang (1990) provide a static model of the acquisition game, and prove the existence of another holdup mechanism. In particular, a triopoly firm attempting to buy both its competitors must offer each firm a duopoly profit, since each firm would become a duopolist by *unilaterally* rejecting the offer. Hence, a profitable merger to monopoly, that is a merger characterized by $\pi(1) > 3\pi(3)$, does not occur if $\pi(1) < \pi(3) + 2\pi(2)$. There are three differences between our holdup mechanism, described in Proposition 1, and the holdup mechanism in Kamien and Zang (1990). Our mechanism affects two-firm mergers, while their holdup mechanism affects mergers involving three firms or more. Second, ours is due to strong positive externalities, while theirs is the result of positive externalities. Third, our mechanism takes the form of delay, while Kamien's and Zang's is absolute–the merger does not even occur in the long run.

There is also a second holdup mechanism in our model.

Proposition 3 *Consider a market where mergers from triopoly (and duopoly) to monopoly are profitable. No merger occurs in equilibrium if the gain from becoming an insider is negative, that is* $(I_{32} + I_{21}/2)/2 < 0$.

[9] Insisting on symmetric equilibria entails that we must accept studying mixed strategy equilibria. We interpret the mixed strategy equilibrium in terms of Harsanyi's (1973) purification theorem, which shows that any mixed strategy equilibrium can "almost always" be obtained as the limit of a pure-strategy equilibrium in a given sequence of slightly perturbed games.

This holdup mechanism is present in area A' in Figure 2. There are two reasons for triopoly not being transformed into monopoly, even though $I_{31} > 0$. First, the merger from triopoly to duopoly is unprofitable ($I_{32} < 0$).[10] Second, the insiders' share of the surplus from the subsequent, and profitable ($I_{21} > 0$), merger from duopoly to monopoly is too small. Together, the insiders only receive half the surplus of the second merger.

Expressed differently, a sequence of mergers from triopoly to monopoly does not occur because the outsider would capture too a large share of the surplus, $I_{31} = [\pi(1) - 3\pi(3)]/r$. There are two reasons why the outsider captures such a large share. First, the merger from triopoly to duopoly may have a positive externality on the outsider, that is $\pi(2^-) > \pi(3)$. Such a positive externality strengthens the outsider's bargaining position (his so-called inside option) in the subsequent merger for monopoly. Second, the outsider free-rides, also in the sense of reaping a positive share (namely half) of the surplus in the merger from duopoly to monopoly, that is $I_{21}/2$. From the industry's point of view, there is a commitment problem. If the outsider could commit not to demand such a large share of the surplus in the negotiations over the merger to monopoly, this holdup mechanism would be mitigated.

The causes behind the holdup mechanism in Propositions 1 and 2 and the one in Proposition 3 are different. The first mechanism is due to the firms' conflicts over the allocation of roles. In the second case, an exogenous allocation of roles does not avoid holdup (there are no asymmetric equilibria in region A'). The problem is the firms' conflict over the split of the surplus.

Kamien and Zang (1993) study sequential mergers in a multi-period extension of their previous model. Holdup also occurs in that model because of

[10] One may question how a merger can be unprofitable. Cannot the merged firm at least replicate the pre-merger strategy? Not necessarily. Mergers motivated by market power may be unprofitable because competitors expand their output in response to such mergers (Szidarovszky and Yakowitz, 1982; Salant, Switzer, and Reynolds, 1983).

conflicts over the surplus. In their model, the split of surplus is not determinate, since there are multiple equilibria. Selecting the equilibrium favoring the insiders the most, they show that holdup exists only in parts of our region A'. In particular, giving the outsider only $\pi(2^-)/r$ in the merger from duopoly to monopoly, there is holdup only if $\pi(1) < \pi(2^-) + 2\pi(3)$. Thus, their holdup mechanism is only due to the positive externality from the merger to duopoly. In our model, the split of the surplus is determined in equilibrium. Since the outsider captures a share of the surplus in the merger from duopoly to monopoly, the holdup mechanism is strengthened.

Actually, in our model, there may be holdup even in the case of negative externalities (area A' extends into the area where $\pi(2^-) < \pi(3)$). Since mergers with negative externalities are typically pro-competitive, this observation raises the concern that the market may fail to induce mergers beneficial to both firms and consumers. Holdup may thus hinder socially desirable mergers.

It might be suspected that the holdup mechanisms would disappear (or at least be mitigated) if firms were allowed to bid for both of their competitors at the same time. Fridolfsson (1998) disproves that conjecture; the argument being the same as in Kamien and Zang (1993). Complete monopolization through a sequence of two-firm mergers is preferred to one three-firm merger. (Hence, no merger or a delayed two-firm merger is preferred to a three-firm merger.) Essentially, in a sequential monopolization, the first target must be compensated for the loss of its triopoly value, that is $W(3)$, and the second for the loss of its duopoly value, that is $W(2^-)$. In a three-firm merger, both targets must be paid the duopoly value. Moreover, $W(2^-)$ is larger than $W(3)$ in the relevant cases.

4 Divestiture as Remedy

Propositions 1 and 2 show that the strong positive externality from anti-competitive mergers creates an obstacle for firms attempting to monopolize a market. It also shows that merger control may nevertheless be valuable, since the merger is only delayed. In this section, we show that when designing a merger policy, the holdup mechanism should be taken into account.

In the past, problematic mergers were often challenged in their entirety. In the US, most cases are today resolved by consent decree where the deal is allowed to close so long as a package of assets sufficiently large to address competitive concern is set aside for divestiture (Baer, 1996). According to Article 8(2) of the EU merger regulation, a merger may be approved provided that the merging firms divest part of their assets. For example, the merger in 1992 between Nestlé and Perrier involved the divestiture of Perrier's subsidiary Volvic to the competitor BSN. In this case, it was the merging firms that proposed the divestiture. However, there is little doubt that the parties to the merger thought that without the divestiture, the European Commission was likely to oppose the takeover (Compte, Jenny and Rey, 1996).

In this section, we investigate the consequences of such divestiture requirements on the merger process and the holdup mechanism. In particular, we are interested in the effect of requiring the merging firms to divest assets to competitors, as in the Nestlé-Perrier merger case. This issue can be analyzed in the context of our model, by changing the rules of the acquisition phase. For simplicity, we assume mergers to monopoly to be blocked by the competition authority ($I_{21}^{*} = 0$). As before, the buyer offers b to the seller. If the seller accepts the offer, the competition authority intervenes and requires some assets to be divested to the outsider. Then, the buyer proposes a price for the assets to be divested. Finally, the outsider either accepts or rejects the offer. If accepted, a duopoly with profit flows $\widetilde{\pi}\left(2^+\right)$ and $\widetilde{\pi}\left(2^-\right)$ is realized (the tilde symbol indicates the profit flows in the duopoly after divestiture). In case the outsider rejects, the triopoly remains for another period. A symmetric Markov perfect equilibrium is characterized by the quintuple (p, b, a, β, α), where β indicates the price at which the buyer proposes the outsider to buy the asset to be divested and α indicates the highest price the outsider will accept. The firms' values at the time of the merger are given by:

$$V^{buy} = W\left(2^+\right) - b + \beta, \tag{16a}$$

$$V^{sell} = b, \tag{16b}$$

$$V^{out} = W\left(2^-\right) - \beta, \tag{16c}$$

where $W\left(2^i\right) = \widetilde{\pi}\left(2^i\right)/r$. All other equations from section 2 remain unchanged. To complete the model, we only need to add two equilibrium conditions. If the outsider rejects offer β, the triopoly remains. Hence, by subgame perfection in the acquisition phase, the highest price accepted by the outsider is given by the external effect, that is

$$\alpha = W\left(2^-\right) - W\left(3\right). \tag{17}$$

Moreover, the bidder's profit is maximized if

$$\beta = W\left(2^-\right) - W\left(3\right). \tag{18}$$

As it turns out, an immediate merger equilibrium exists (as $\Delta \to 0$) if, and only if, the aggregate profit in the duopoly is larger than the aggregate profit in the triopoly, that is $\widetilde{\pi}\left(2^+\right) + \widetilde{\pi}\left(2^-\right) \geq 3\pi\left(3\right)$. A no merger equilibrium exists if, and only if, $\widetilde{\pi}\left(2^+\right) + \widetilde{\pi}\left(2^-\right) \leq 3\pi\left(3\right)$. Thus, the holdup friction has vanished.

Proposition 4 *Assume that mergers to monopoly are illegal. A policy approving mergers to duopoly, conditional on the buyer divesting assets to the outsider, hastens merger to duopoly, compared to the policy approving mergers to duopoly without conditions.*

The intuition for this result is that the competition authority introduces a channel for transfer of wealth from the outsider to the merging firms. In particular, the outsider is willing to pay a high price for the divested assets, since the alternative is that the merger is blocked. Hereby, the insiders can extract the positive externality from the outsider, and participating in a merger becomes more profitable than standing outside. As a consequence, the free rider friction disappears.

If competition authorities are well-informed, the divestiture policy increases social welfare. Indeed, if a merger to the "best duopoly" increases social welfare relative to the triopoly, then the merger (with divestiture) is carried out, and it is carried out immediately. If, on the other hand, the "best duopoly" decreases social welfare relative to the triopoly, the authority need only forbid it. There is only one restriction, the competition authority must order a divestiture satisfying $\widetilde{\pi}(2^{+}) + \widetilde{\pi}(2^{-}) \geq 3\pi(3)$.

In reality, however, competition authorities do not have detailed knowledge about the welfare effects of mergers. Instead, they rely on threshold concentration levels (in terms of market shares or the Herfindahl index) for approving mergers. Obviously, such policies may block welfare increasing mergers and approve welfare decreasing ones. In such a context, Proposition 4 points at a potential problem. Divestiture of assets from the larger merged entity to the smaller outsider reduces concentration. In some markets, a merger with divestiture keeps concentration below the threshold, while the same merger without divestiture violates the threshold. In such markets, divestiture hastens mergers whether they improve welfare or not.

5 Merger Control and Intertemporal Links

The incentives for mergers in less concentrated markets are affected by the expected merger activities in more concentrated markets. Such intertemporal links have additional implications for merger policy.

5.1 Concentration Based Policies

Consider a merger policy formulated in terms of a threshold concentration level. Since the welfare maximizing level of concentration differs between different markets, such threshold levels imply that some markets will become more concentrated and some less, than the socially optimal level. To be concrete, the policy forbidding monopoly but not duopoly is too strict for markets with very strong scale economies, but too lax for markets with milder economies of scale. However, there is also a less obvious cost of concentration based policies, due to the intertemporal links in merger formation.

An implication of Lemma 1 is that mergers from triopoly to duopoly may be hastened or delayed by the expectation of a subsequent merger to monopoly, due to two opposing effects. First, the net gain to insiders of the first merger is larger than otherwise, since $\partial I/\partial I_{21}^{*} > 0$, which tends to increase Θ and hasten a merger. Second, the net gain for the outsiders in the first merger is also larger than otherwise, since $\partial E/\partial I_{21}^{*} > 0$, which tends to decrease Θ and to delay a merger. The next proposition identifies the conditions under which the latter effect dominates the former.

Proposition 5 *Assume all mergers to be profitable [$I_{32} > 0$, $I_{21} > 0$, and $I_{31} > 0$]. If competition authorities block mergers to monopoly but not to* *duopoly, then the expected delay for a merger from triopoly to duopoly is lower than under a laisser faire regime, if* $\pi(2^{+}) - \pi(2^{-}) \geq \pi(3)$.

In an industry where social welfare is higher the less concentrated is the market, forbidding mergers to monopoly is expected to be better than not controlling mergers at all. However, Proposition 5 shows that this need not be the case. On the one hand, forbidding merger to monopoly decreases the concentration in the final market structure (duopoly rather than monopoly) which is a welfare gain. On the other hand, the triopoly remains for a shorter period of time when mergers to monopoly are forbidden, which is a welfare cost.

5.2 The Case-by-Case Policy

Consider the policy to allow a proposed merger if, and only if, it is welfare increasing. This case-by-case policy is optimal if each merger is analyzed in isolation and has also been the focus of all earlier welfare analyses of mergers, since those studies have been based on the exogenous merger approach (Williamson, 1968; Farrell and Shapiro, 1990; Barros and Cabral, 1994). In an endogenous merger framework, however, the case-by-case policy need not be optimal.

To illustrate the non-optimality of the case-by-case policy, we use an example of a market where mergers to duopoly generate cost savings. In particular, it is assumed that a merger from triopoly to duopoly reduces marginal costs due the adoption of a superior technology. The knowledge of the new technology fully spills over to the outsider at zero cost.[11] Merged

[11] We think of the cost reduction as the result of R&D in duopoly. The incentives for R&D are larger in duopoly (and monopoly) than in triopoly for two reasons. The spillover effect is less of a problem when fewer firms free-ride, and less of the cost savings are passed on to consumers via a lower price in a concentrated market.

firms are assumed to be more complex which materializes into higher fixed costs. The example is formalized in Appendix B.

In this market, a merger from triopoly to duopoly increases social welfare and would be accepted. The reason is that the efficiency gains in the form of reduced marginal costs dominate both the dead weight loss associated with increased concentration and the increase in fixed costs. For the same reason, monopoly dominates triopoly in welfare terms. In contrast, a merger from duopoly to monopoly reduces social welfare and hence, would not be accepted. There is only increased market power, without any additional cost savings. Thus, from a social welfare point of view:

$$\text{duopoly} \succ \text{monopoly} \succ \text{triopoly}. \tag{19}$$

In this market, a merger from triopoly to duopoly is unprofitable for two reasons; the merged firm has higher fixed costs, and the outsider expands its output. The two beneficial effects (increased market power and reduced costs) are dominated by the negative ones. A merger from duopoly to monopoly is profitable due to increased market power and, as a result, the firms do not merge to duopoly, if the merger to monopoly is blocked. However, there would be delayed mergers to monopoly under a laisser faire regime (area B' in Figure 2).

In this market, a laisser faire regime leads to monopoly, while the case-by-case policy results in triopoly. Hence:

Proposition 6 *Assume the welfare ranking between the different market structures to be given by (19). Assume that mergers to duopoly are unprofitable, but that mergers from triopoly to monopoly via duopoly occur absent merger control. The policy to allow mergers if, and only if, they are welfare increasing, in effect, also blocks mergers from triopoly to duopoly, and hence* *is inferior to a laisser faire regime.*

The decision not to allow the merger from duopoly to monopoly is motivated by a comparison between the monopoly and the duopoly. However, if the firms understand the policy and can predict the future behavior of competition authorities, the relevant alternative to monopoly is triopoly.

Unfortunately, taking the intertemporal link between different mergers into account is difficult for at least two reasons. First, when a merger (from duopoly to monopoly) is proposed, the competition authority must look back in time and assess which mergers (that have already taken place) would not have occurred if the proposed merger were to be blocked. Such a policy obviously requires that competition authorities have access to a very large amount of information. In particular, more information is needed than for implementing the case-by-case policy. Second, once the socially beneficial merger has taken place, it is actually better to block the merger to monopoly. Hence, in order to implement the optimal policy, the competition authorities must be able to credibly commit not to use the case-by-case policy.

6 Concluding Remarks

Anti-competitive mergers benefit competitors more than the merging firms. We demonstrate that such externalities reduce firms' incentives to merge. Firms delay merger proposals, thereby foregoing valuable profits and hoping other firms will merge instead - a war of attrition. The final result, however, is an overly concentrated market. We also demonstrate how merger incentives may be reduced by the prospect of participating in additional, future, profitable mergers.

These results are derived in a model of endogenous mergers. In particular, we construct a so-called game of timing for describing the bargaining process.[12] In the model, any firm can submit a merger proposal to any other firm(s) at any point in time. The recipient(s) of a proposal can either accept or reject it. In the latter case, the recipient can make a counterproposal in the future. As a consequence, firms endogenously decide whether and when to merge, and how to split the surplus, while keeping other possible mergers in mind.[13]

Since the holdup mechanism only creates temporary frictions to monopolization, merger control may play an important part for preserving competitive markets. Even reasonable policies may, however, be worse than not controlling mergers at all.

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[12] Games of timing have previously been used for analyzing both "wars of attrition" and thier opposite, preemption. Examples include studies of patent races (Fudenberg, Gilbert, Stiglitz, and Tirole 1983), adoptation of new technology (Fudenberg and Tirole 1985), exit from declining industries (Ghemawat and Nalebuff 1985), choice of compatibility standards (Farrell and Saloner 1988), and entry (Bolton and Farrell 1990).

[13] This model is a generalization of the Rubinstein-Ståhl bargaining model, not only because it concerns coalition formation (with more than two agents, competing "pies", and so on), but also because the order of proposals is endogenous. In three companion papers, we apply the model to study three empirical phenomena: why unprofitable mergers occur, why mergers occur in waves, and why event studies do not detect anti-competitive mergers (Fridolfsson and Stennek, 2000a, 2000b and 2000c).

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A Proofs

A.1 Preliminaries

Lemma 3 *Let* $m \sim Bin\,(n-1,(n-1)\,p)$*. When* $p>0$*,*

$$E\left\{\frac{1}{m+1}\right\}=\frac{1}{n\,(n-1)\,p}\left[1-(1-(n-1)\,p)^{n}\right].$$

When $p=0$*,* $E\left\{\frac{1}{m+1}\right\}=1$*.*

Proof: Consider the case when $p>0$. Let $s \sim Bin\,(t,r)$. Then, by definition

$$E\left\{\frac{1}{s+1}\right\}=\sum_{s=0}^{t}\frac{t!}{s!\,(t-s)!}r^{s}\,(1-r)^{t-s}\left(\frac{1}{s+1}\right).$$

Note that $s!\left(\frac{1}{s+1}\right)=(s+1)!$. Hence:

$$E\left\{\frac{1}{s+1}\right\}=\frac{1}{r}\sum_{s=0}^{t}\frac{t!}{(s+1)!\,(t-s)!}r^{s+1}\,(1-r)^{t-s}.$$

Let $a-1=t$:

$$E\left\{\frac{1}{s+1}\right\}=\frac{1}{r}\sum_{s=0}^{a-1}\frac{(a-1)!}{(s+1)!\,(a-1-s)!}r^{s+1}\,(1-r)^{a-1-s}.$$

Let $b=s+1$:

$$E\left\{\frac{1}{s+1}\right\}=\frac{1}{r}\sum_{b=1}^{a}\frac{(a-1)!}{b!\,(a-b)!}r^{b}\,(1-r)^{a-b}.$$

Multiply and divide by a:

$$E\left\{\frac{1}{s+1}\right\}=\frac{1}{ra}\underbrace{\sum_{b=1}^{a}\frac{a!}{b!\,(a-b)!}r^{b}\,(1-r)^{a-b}}_{=1-\Pr\{b=0\}\text{ where } b\sim Bin(a,r)}.$$

Since $1-\Pr\{m=0\}=1-(1-r)^{a}$, we have

$$E\left\{\frac{1}{s+1}\right\}=\frac{1}{ra}\left[1-(1-r)^{a}\right]=\frac{1}{r}\frac{1}{t+1}\left[1-(1-r)^{t+1}\right].$$

Now, let $s=m$ and $t=n-1$ and $r=(n-1)\,p$ to get the required expression. Finally, when $p=0$, m deterministically equals 0. QED.

Lemma 4 *Let*

$$\xi\,(p)\equiv\frac{1}{6}\frac{\Pr\{m=0\}-E\left\{\frac{1}{m+1}\right\}}{\frac{1}{3}\Pr\{m=0\}+E\left\{\frac{1}{m+1}\right\}}. \tag{20}$$

Then, since $n=3$*,*

i. $\xi\,(0)=0$

ii. $\xi\left(\frac{1}{2}\right)=-\frac{1}{6}\leq 0.$

iii. $\xi'\,(p)\leq 0.$

iv. $\lim_{p\to 0}\xi'\,(p)=-1/4<\infty.$

Proof: By Lemma 3, it follows that

$$\xi\,(p)=\frac{-p\,(3-4p)}{6\,(2-5p+4p^{2})},$$

since $n=3$. Properties *i.* and *ii.* follow immediately. Moreover

$$\xi'\,(p)=-\frac{1}{3}\frac{3-8p+4p^{2}}{(2-5p+4p^{2})^{2}}\leq 0.$$

Properties *iii.* and *iv.* follow, since $p\in[0,1/2]$. QED.

A.2 Proof of Lemma 1

We only provide a proof of Lemma 1 for the case when $I_{21}^* = 0$. When $I_{21}^* > 0$, the proof is similar and therefore omitted. There is one additional complication, however, namely that Θ is a function of Δ.

We start the proof by rewriting the definitions of $W(2^i)$, $W(3)$, $EV(b)$ and $EV(nb)$. Since $I_{21}^* = 0$, equation (2) simplifies to

$$W\left(2^i\right) = \pi\left(2^i\right)/r \tag{21}$$

for $i \in \{+,-\}$. Moreover, let $d = e^{-r\Delta}/\left(1 - e^{-r\Delta}\right)$, substitute (3a)-(3c) into (4) and rearrange:

$$W(3) - \frac{1}{r}\pi(3) = 2qd\left[W\left(2^+\right) + W\left(2^-\right) - 3W(3)\right]. \tag{22}$$

Furthermore, by lemma 3, when $p > 0$ and $n = 3$,

$$E\left\{\frac{1}{m+1}\right\} = \frac{1-(1-2p)^3}{6p}. \tag{23}$$

Note also that $E\left\{\frac{m}{m+1}\right\} = 1 - E\left\{\frac{1}{m+1}\right\}$. Hence,

$$EV(b) = V^{buy}E\left\{\frac{1}{m+1}\right\} + \left[1 - E\left\{\frac{1}{m+1}\right\}\right]\left[V^{sell} + V^{out}\right]\left(\frac{1}{2}\right). \tag{24}$$

$$EV(nb) = W(3)\Pr\{m=0\} + \left[1 - \Pr\{m=0\}\right]\left[V^{out} + V^{sell}\right]\left(\frac{1}{2}\right). \tag{25}$$

An **immediate-merger** equilibrium is characterized by $p = 1/2$. By equation (5), we have $q = 1/6$. By equation (22), we have $W(3) = \left[W(2^+) + W(2^-)\right]/3$ when $\Delta \to 0$ (that is $d \to \infty$), since $W(3)$ is bounded. By equation (23), $E\left\{\frac{1}{m+1}\right\} = 1/3$. By equation (24) and the fact that $V^{sell} = b = W(3)$, we have $EV(b) = \left[W(2^+) + W(2^-)\right]/3$. By equation (25), we have $EV(nb) = W(2^+)/6 + 4W(2^-)/6$ since $\Pr\{m=0\} = 0$. Hence, by equation (21), $EV(b) \geq EV(nb)$ if and only if $\pi(2^+) \geq 2\pi(2^-)$.

A **no-merger** equilibrium is characterized by $p = 0$. By equation (5), we have $q = 0$. By equation (22), we have $W(3) = \pi(3)/r$. By Lemma 3, $E\left\{\frac{1}{m+1}\right\} = 1$. By equation (24), we have $EV(b) = W(2^+) - \pi(3)/r$. By equation (25), we have $EV(nb) = \pi(3)/r$ since $\Pr\{m = 0\} = 1$. Hence, by equation (21), $EV(b) \leq EV(nb)$ if and only if $\pi(2^+) \leq 2\pi(3)$.

A **delayed-merger** equilibrium is characterized by $p \in (0, 1/2)$. Equating the expected value of bidding, given by equation (24), and the expected value of not bidding, given by equation (25), and rearranging, we have that

$$W(3) = \frac{W(2^+)}{2} - 2\xi(p)\left[\frac{W(2^+)}{2} - W\left(2^-\right)\right] \tag{26}$$

where ξ is defined in Lemma 4 above.

Consider first, the interesting case, characterized by $\pi(3)/r \neq [W(2^+) + W(2^-)]/3$. By (22), it follows that $W(3) \neq [W(2^+) + W(2^-)]/3$. To prove this, assume the opposite. Then, the right-hand side of equation (22) is zero. Hence, $W(3) = \pi(3)/r$. In turn, $\pi(3)/r = [W(2^+) + W(2^-)]/3$ which is a contradiction. Similarly, we can prove that $W(3) \neq \pi(3)/r$. By (26), it follows that $W(2^+)/2 \neq W(2^-)$ for all $p \in (0, 1/2)$, since $\xi(p) \leq 0$. Consequently, by equation (21), $\Theta = 3\frac{\pi\left(2^+\right) - 2\pi(3)}{\pi(2^-) - \pi(2^+)/2}$ is finite.

Use (22) to solve for q:

$$q = \frac{W(3) - \frac{1}{r}\pi(3)}{W(2^+) + W(2^-) - 3W(3)} \frac{1}{2d}.$$

Use (26) to eliminate $W(3)$, and (21) to eliminate $W(2^i)$, and rearrange:

$$q = \frac{\left[\frac{1}{2}\pi(2^+) - \pi(3)\right] + \xi(p)\, 2\left[\pi(2^-) - \frac{1}{2}\pi(2^+)\right]}{\left[\pi(2^-) - \frac{1}{2}\pi(2^+)\right] - \xi(p)\, 6\left[\pi(2^-) - \frac{1}{2}\pi(2^+)\right]} \frac{1}{2d}.$$

Divide by $\left[\pi(2^-) - \frac{1}{2}\pi(2^+)\right]$ and use the definition of Θ:

$$q = Q(p, \Delta) \equiv \frac{\Theta + 6\xi(p)}{1 - 6\xi(p)} \frac{1}{6d(\Delta)}. \tag{27}$$

Moreover, according to equation (5):

$$q = \widetilde{Q}(p) \equiv \frac{1-(1-2p)^3}{6}$$

The equilibrium values of p are determined by

$$Q(p) = \widetilde{Q}(p). \tag{28}$$

Note that $\widetilde{Q}(0) = 0$ and $\widetilde{Q}\left(\frac{1}{2}\right) = \frac{1}{6}$ and that the function $\widetilde{Q}(p)$ is monotonically increasing.

Assume first that $\Theta > 0$. Since $\xi(0) = 0$ and $\xi\left(\frac{1}{2}\right) = -\frac{1}{6}$ (according to Lemma 4), it follows that $Q(0,\Delta) = \frac{2\Theta}{12}\frac{1}{d}$ and $Q\left(\frac{1}{2},\Delta\right) = \frac{\Theta-1}{12}\frac{1}{d}$. Since $\xi'(p) \leq 0$ (according to Lemma 4) and $Q_p(p,\Delta) = \frac{\xi'(p)}{(1-6\xi)^2}[1+\Theta]\frac{1}{d}$ it follows that $Q(p,\Delta)$ is monotonically decreasing. Since

$$\begin{aligned} Q(0,\Delta) &= \tfrac{2\Theta}{12}\tfrac{1}{d} > 0 = \widetilde{Q}(0) \\ Q\left(\tfrac{1}{2},\Delta\right) &= \tfrac{\Theta-1}{12}\tfrac{1}{d} < \tfrac{1}{6} = \widetilde{Q}\left(\tfrac{1}{2}\right) \end{aligned}$$

where the second inequality is true for d sufficiently big (Δ sufficiently small), it follows by continuity and monotonicity that there exists a unique p such that $Q(p,\Delta) = \widetilde{Q}(p)$. Moreover, it follows from equation (27) that $p, q \to 0$ as $\Delta \to 0$ ($d \to \infty$).

Assume now that $\Theta = 0$; then the above analysis is still valid. However, note that $Q(0,\Delta) = \frac{2\Theta}{12}\frac{1}{d} = 0$ so that $p = 0$, contradicting $p \in (0, 1/2)$. Assume now that $-1 \leq \Theta < 0$. Then, $Q(0,\Delta) < 0$ and since $Q(p,\Delta)$ is monotonically decreasing, there does not exist any p such that $Q(p,\Delta) = \widetilde{Q}(p)$. Assume now that $\Theta < -1$. Then $Q\left(\frac{1}{2},\Delta\right) = \frac{\Theta-1}{12}\frac{1}{d} < 0$ and since $Q(p,\Delta)$ is monotonically increasing, there does not exist any p such that $Q(p,\Delta) = \widetilde{Q}(p)$.

Finally, consider a delayed merger equilibrium characterized by $\pi(3)/r = [W(2^+) + W(2^-)]/3$. By (22), it follows that $W(3) = [W(2^+) + W(2^-)]/3$

and $W(3) = \pi(3)/r$ since $1 + 6qd \neq 0$. By (26), it follows that $W(2^+)/2 = W(2^-)$ since $\xi(p) \leq 0$. By equation (21), $W(2^+)/2 = W(2^-)$ if and only if $I_{32}/2 = E_{32}$. Since $W(2^+)/2 = W(2^-)$ it follows by equation (26) that $W(3) = W(2^+)/2$. But $W(3) = \pi(3)/r$, and consequently, it follows that $W(2^+)/2 = \pi(3)/r$ which, by equation (21), is equivalent to $I_{32}/2 = 0$ (hence both the nominator and the denominator of Θ are zero). Hence $EV(b) = EV(nb)$, that is, equation (26) is satisfied, if and only if $I_{32}/2 = E_{32} = 0$. Note also that in this case, any $p \in (0, 1/2)$ is an equilibrium. Hence, unless $p \to 0$ as $\Delta \to 0$, this delayed merger is essentially immediate. Moreover, since $I_{32}/2 = E_{32} = 0$ characterizes a non-generic parameter configuration, we disregard this possibility. QED.

A.3 Proof of Lemma 2

Again, we only provide a proof for the case when $I_{21}^* = 0$. When $I_{21}^* > 0$, the proof is similar, although Θ being a function of Δ once more implies an additional complication.

By definition

$$G_0(t) = \lim_{\Delta \to 0} [q_0(\Delta)]^{t/\Delta}.$$

Since the logarithm is continuous

$$\ln G_0(t) = t \lim_{\Delta \to 0} \frac{\ln q_0(\Delta)}{\Delta}.$$

Note that $\lim_{\Delta \to 0} q_0(\Delta) = \lim_{\Delta \to 0} (1 - 6q(\Delta)) = 1$. Hence, $\lim_{\Delta \to 0} \frac{\ln q_0(\Delta)}{\Delta} =$ "$\frac{0}{0}$". By l'Hopital's rule: $\lim_{\Delta \to 0} \frac{\ln q_0(\Delta)}{\Delta} = \lim_{\Delta \to 0} \frac{q_0'(\Delta)}{q_0(\Delta)} = \lim_{\Delta \to 0} q_0'(\Delta)$. Hence:

$$\ln G_0(t) = t \lim_{\Delta \to 0} q_0'(\Delta).$$

Use equation (27) and $q_0 = 1 - 6q$ and rearrange to get

$$q_0(\Delta) = \frac{e^{-r\Delta}(1 + \Theta) - (\Theta + 6\xi(p(\Delta)))}{e^{-r\Delta}(1 - 6\xi(p(\Delta)))} \tag{29}$$

Let $\xi^{\Delta}(\Delta) = \xi'(p(\Delta))\, p'(\Delta)$. If $\lim_{\Delta\to 0} \xi^{\Delta}(\Delta)$ is finite, then

$$\lim_{\Delta\to 0} q_0'(\Delta) = -r\Theta,$$

hence

$$\ln G_0(t) = -r\Theta t.$$

and consequently $G_0(t) = e^{-r\Theta t}$, as claimed.

It remains to be shown that $\lim_{\Delta\to 0} \xi^{\Delta}(\Delta) = \lim_{\Delta\to 0} \xi'(p(\Delta))\, p'(\Delta)$ is finite. By Lemma 4, $\lim_{\Delta\to 0} \xi'(p(\Delta))$ is finite, and thus it remains to be shown that $\lim_{\Delta\to 0} p'(\Delta)$ is finite. Remember that equilibrium p is determined by equation (28). Hence,

$$\frac{dp}{d\Delta} = \frac{Q_{\Delta}}{\widetilde{Q}_p - Q_p}. \tag{30}$$

Note that

$$Q_{\Delta} = \frac{\Theta + 6\xi(p)}{1 - 6\xi(p)} \frac{1}{6} r \left[1 + \frac{1}{d}\right]$$

and hence $\lim_{\Delta\to 0} Q_{\Delta} = r\Theta/6$, since $p \to 0$ as $\Delta \to 0$. Moreover,

$$Q_p = \frac{18\xi'(p)}{[3 - 18\xi(p)]^2} [1 + \Theta] \frac{1}{2d}$$

and hence $\lim_{\Delta\to 0} Q_p = 0$. Finally, $\widetilde{Q}_p = (1-2p)^2$ and hence $\lim_{\Delta\to 0} \widetilde{Q}_p = 1$. Hence:

$$\lim_{\Delta\to 0} \frac{dp}{d\Delta} = \frac{r\Theta}{6}. \tag{31}$$

QED.

A.4 Proof of Proposition 5

Assume that $I_{21} \geq 0$, $I_{31} \geq 0$ and $I_{32} \geq 0$. Note (in Figure 2) that for some parameter configurations, there is an immediate merger to duopoly independent of whether there is a subsequent merger to monopoly. For some other parameter configurations, there is immediate merger to duopoly if there is no subsequent merger to monopoly, otherwise a delayed merger to duopoly. These cases satisfy $\pi(2^+) \geq \pi(3) + \pi(2^-)$.

The more difficult case is when there is delay independent of whether there is a subsequent merger to monopoly. Since $\Theta = 3\frac{\frac{I_{32}}{2}+\frac{I_{21}}{4}}{E_{32}+\frac{I_{21}}{2}-\left(\frac{I_{32}}{2}+\frac{I_{21}}{4}\right)}$ when a subsequent merger to monopoly is allowed, we have

$$\frac{\partial\Theta}{\partial I_{21}} = \frac{1}{3}\Theta^2\left(\frac{E_{32}+\frac{I_{21}}{2}}{\frac{I_{32}}{2}+\frac{I_{21}}{4}}\right)\left[\frac{1}{4\left(\frac{I_{32}}{2}+\frac{I_{21}}{4}\right)} - \frac{1}{2\left(E_{32}+\frac{I_{21}}{2}\right)}\right].$$

Since $E_{32}+\frac{I_{21}}{2}$ and $\frac{I_{32}}{2}+\frac{I_{21}}{4}$ are both positive when $\Theta > 0$ and $I_{31} \geq 0$, the sign of the partial derivative is determined by the term within brackets. Note that

$$\frac{1}{4\left(\frac{I_{32}}{2}+\frac{I_{21}}{4}\right)} - \frac{1}{2\left(E_{32}+\frac{I_{21}}{2}\right)} \geq 0 \Leftrightarrow \pi\left(2^+\right) \leq \pi(3) + \pi\left(2^-\right).$$

When a subsequent merger to monopoly is not allowed, $\Theta = 3\frac{\frac{I_{32}}{2}}{E_{32}-\frac{I_{32}}{2}}$. Hence, the merger to duopoly is hastened by the expectation of a subsequent merger to monopoly, that is

$$3\frac{\frac{I_{32}}{2}+\frac{I_{21}}{4}}{E_{32}+\frac{I_{21}}{2}-\left(\frac{I_{32}}{2}+\frac{I_{21}}{4}\right)} \geq 3\frac{\frac{I_{32}}{2}}{E_{32}-\frac{I_{32}}{2}},$$

if $\pi(2^+) \leq \pi(3) + \pi(2^-)$, and delayed otherwise. QED.

B Example

Inverse demand is given by $p = 1 - Q$, where $Q = \sum_i q_i$. Up to a capacity constraint $\overline{q} = 1/3$, each firm in the triopoly has a production cost cq_i where $c < 1$. After a merger to duopoly, the merged entity's marginal cost is reduced to zero (due to the learning of a superior technology) while it also incurs a fixed cost f (since larger firms are more complex to manage). The outsider's marginal cost is also reduced to zero, due to technological spillovers. However, unlike the merged entity, the outsider does not incur an additional fixed cost.

Firms compete à la Cournot. Given that the capacity constraints are non-binding, each firm produces $q_i = (1-c)/(1+n)$ in equilibrium and the gross profit (not including fixed costs) is given by $\pi_i = (1-c)^2/(1+n)^2$ (set $c = 0$ in case a merger has occurred). The consumers' surplus is given by $Q^2/2$ and social welfare is measured as the sum of consumers' and producers' surpluses. The capacity constraints are never binding (see below). Thus, the triopoly profit is $\pi(3) = (1-c)^2/16$ and the duopoly profits are $\pi(2^+) = 1/9 - f$ and $\pi(2^-) = 1/9$, respectively. In the monopoly, the profit is $1/4 - f$.

If a merger from duopoly to monopoly takes place, the monopoly either shuts down the outsider's plant or the insiders' plants. Keeping both is not optimal, if larger firms induce higher fixed costs. In the former case, the monopoly produces with the merged entity's technology, characterized by the high capacity constraint $2\overline{q}$ and the fixed cost f. The profit is $1/4 - f$. In the latter case, it produces with the outsider's technology, with capacity constraint $\overline{q}$ and zero fixed cost. The profit would be $(1-\overline{q})\,\overline{q} = 2/9$. Thus, the monopoly profit is $\pi(1) = 1/4 - f$ if $f < 1/36$ (C1). The only role of the capacity constraints is to ensure that the monopolist closes down the outsider's plant.

A merger from triopoly to duopoly is not profitable if $f > 1/9 - (1-c)^2/8$ (C2). A merger from duopoly to monopoly is always profitable and a sequence of mergers to monopoly occurs under a laisser faire regime if $f < \left[1-(1-c)^2\right]/8$ (C3). Finally, social welfare is always higher in duopoly than in monopoly, while social welfare in monopoly is higher than in triopoly if $f < 3/8 - 15(1-c)^2/32$ (C4). Let $c = 0.14$ and $f = 0.02$. Then conditions (C1)-(C4) are all fulfilled.