On the Profitability of Horizontal Mergers in Industries with Dynamic Competition

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Abstract

The consequences of horizontal mergers on firms' profits are traditionally studied within a static Cournot framework. In such a setting the merger is modelled as an exogenous change in market structure. One of the key results in this literature is that if firms compete in a homogeneous product market, mergers will in general be unprofitable to the merging firms. In this paper we analyze horizontal mergers of firms that compete in a dynamic Cournot market. We find unlike in static Cournot models that mergers are always profitable independent of the number of merging firms. While firms have an incentive to merge, welfare in the economy, however, does not increase since the gain in producer surplus does not offset the loss in consumer surplus due to increased prices.

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1 Introduction

Ever since the beginning of industrialization, market economies have undergone different types of merger waves with different intensities and with different affects to various industries. Because of this, economists always were and still are interested in studying the welfare consequences of mergers. Basic intuition would suggest that a merger decreases the level of competition, and hence increases the price for the product, but part of this welfare loss to consumers can be offset by increased profits to the merging firms.

In a well received paper Salant, Switzer and Reynolds (1983) (SSR) demonstrate that in a static Cournot model with linear demand and cost functions, merger are unprofitable unless they involve at least 80% of the firms in the industry. The intuition for this result is simple: In a static Cournot market a merger causes the insiders to reduce output and hence the price to increase. Given that the competitive position of the firms in the industry is characterized by strategic substitutes the reaction of the outsider firms will be to increase quantity and hence reduce the profit increase of the insiders. In case of linear costs the output expansion of the outsiders will be large enough to even offset the price and hence the profit increase of the merging firms.[2] While this result is very interesting, several shortcomings of the SSR analysis need to be pointed out. Firstly, Deneckere and Davidson (1985) show that if firms produce differentiated products and compete by setting prices instead of quantities, any price increase by the merging firms is matched by the outsiders and hence a merger becomes profitable. Secondly, as some other papers point out, the conclusion of SSR is directly linked to their modelling of the cost structures. If a merger implies that the merging entity can draw upon some scale economies of all merging firms cost reductions will ensure the profitability of mergers. Perry and Porter (1985) present a model that builds on these arguments. Their merging firms have access to a tangible asset that is acquired from the merging partners so that the merged firm can increase output at a given level of average costs and hence benefits from the merger. While Perry and Porter analyze the importance of the cost structure for a merger to be profitable Farrell and Shapiro (1990) study two related problems: (i) Under what conditions does a horizontal merger result in a price increase? (ii) What are the welfare consequences of a merger to the (external) nonparticipating agents (outsiders and consumers)? They find that a merger will always result in a price increase when it does not create synergies and they provide a sufficient condition for profitable mergers to raise overall welfare.

The issue of profitable horizontal mergers is also addressed in a paper by Gaudet and Salant (1991). They analyze the general conditions under which an exogenous output contraction to a subset of firms competing in an oligopolistic market is profitable. It turns out that a marginal reduction in output to a subset of firms increases their profits, if the number of firms in the subset does not exceed an adjusted number of firms outside the subset. In case of linear costs this results in the 80% rule of SSR.

[2]It should be pointed out that the unprofitability proposition shown by SSR was already discussed at a more intuitive level by Stigler (1950).

The main conclusions of the papers summarized so far is, that profitable mergers require the realization of strong synergies. The reduction in competition alone cannot be a motive since it only benefits the outsiders but not the merging firms. In this paper we point out that this view of the anticompetitive forces in a merger is not valid, in general. On the contrary, we find that in a *dynamic* Cournot game where firms use Markovian strategies (i.e. firms set their quantities as decision rules that depend on the current level of price) mergers are always profitable even if there are no cost synergies of the merging firms. Hence, we show that the anticompetitive forces due to a merger can be strong enough to benefit both the outsiders and the insiders. The intuition for this result is the following. If firms compete in a dynamic Cournot market equilibrium quantities are higher than in a static Cournot model and hence the corresponding equilibrium price is closer to marginal costs, i.e. the Bertrand equilibrium outcome. In this sense dynamic Cournot competition resembles more Bertrand like behaviour, and we know that mergers are generally profitable in this case.

It is important to point out that our analysis does not provide a complete theory of horizontal mergers. All we demonstrate is that in a classical Cournot framework the nature of competition is crucial for understanding the anticompetitive force as a motive for mergers.[3] While in the static version of our model it turns out that a merger never benefits the insiders, multiperiod competition does lead to increases in profits for both the insiders and the outsiders.

A better understanding of the whole merger process within and across industries requires to simultaneously model firm and industry dynamics explicitly and derive mergers as the result of endogenous firm behaviour rather than an exogenous change in the number of firms competing in an industry. In a recent paper Gowrisankaran (1999) introduced a dynamic model of endogenous horizontal mergers. Building on a model by Ericson and Pakes (1995) he looks at dynamic firm decisions and industry evolution according to the following four stages: (i) mergers, (ii) exit of the industry, (iii) production, and (iv) investment and entry. In this general setting the equilibrium behaviour of firms with and without a merger process is analyzed. It turns out that allowing for mergers changes the evolution of an industry by not only making it more concentrated but also by increasing its capacity to respond to external shocks. Moreover it is also found that mergers will generally increase producer surplus but not because of an anticompetitive force like in our paper but because of the ability of the merged firms to better cope with bad investments and to prevent a possible deadweight loss arising from an exit. As for consumer surplus it is shown that it will allways decrease because of higher concentration in the industry and therefore higher prices.

[3]We want to point out that Kwoka (1989) already studied the consequences of the nature of competition for the profitability of a merger but within a static framework. He uses a static conjectural variations approach to model different types of competition and finds that as long as the conjectures are not too high (the industry is closer to a competitive level) mergers are profitable. The are two main points of criticism to this approach, however. Fristly, it is difficult to justify exogenously set conjectures from an economic point of view and secondly, profitability of mergers in the Kwoka (1989) analysis occurs only for very limited cases with strong assumptions on the level of static conjectures.

Our paper is organized as follows. In the next section we introduce the model. We use the differential game model introduced by Fershtman and Kamien (1987) but reformulate it as a continuous time repeated game with an infinite time horizon. In Section 3 we derive the premerger equilibrium and in Section 4 we study the profitability and the welfare implications of horizontal mergers in a market with dynamic competition. Section 5 summarizes the main findings and points out some future research.

2 A Dynamic Oligopoly Model

Consider a dynamic oligopoly market with N symmetric firms each supplying a homogeneous output. Firms are assumed to produce with concave technologies described by the quadratic cost functions

$$C(q_i(t)) = cq_i(t) + \frac{1}{2}q_i^2(t), \qquad i = 1, \ldots, N, \tag{1}$$

where $q_i(t) \geq 0$ is the output of firm i produced at time t and c is a positive constant. The product price, $p(t)$, in period t is related to industry output by means of the inverse demand function

$$p(t) = a - \sum_{i=1}^{N} q_i(t), \tag{2}$$

where the units of measurement are chosen such that the slope of the demand curve is -1. Combining (1) and (2) the single period profit function of firm i is given by

$$\pi_i(q_1(t), \ldots, q_N(t)) = [a - \sum_{j=1}^{N} q_j(t)]q_i(t) - cq_i(t) - \frac{1}{2}q_i^2(t). \tag{3}$$

Equation (3) represents a classical one-shot Cournot game. It is easily shown that this game has a unique symmetric Nash equilibrium in pure strategies resulting in equilibrium quantities given by $q_i = \frac{a-c}{N+2}$. Equilibrium profits (under the assumption of entry barriers) are given by

$$\pi_i = \frac{3}{2}\left(\frac{a-c}{N+2}\right)^2. \tag{4}$$

Since we are interested in the relationship between dynamic Cournot competition and the profitability of horizontal mergers, we use the continuous time repeated version of the Cournot game and study Markov-perfect equilibria of this model. To this end we borrow the "sticky price" model analyzed by Fershtman and Kamien (1987). In this game, each firm maximizes its infinite discounted stream of profits given by

$$\max_{q_i} \Pi_i = \max_{q_i} \int_0^{\infty} e^{-rt}[p(t)q_i(t) - cq_i(t) - \frac{1}{2}q_i^2(t)]\, dt \tag{5}$$

subject to

$$\dot{p}(t) = s[a - \sum_{j=1}^{N} q_j(t) - p(t)]; \quad p(0) = p_0. \tag{6}$$

where $r > 0$ is the constant discount rate. Equation (6) implies that the actual market price deviates from its level given by the demand function but moves towards it with a constant speed of adjustment denoted by s $(0 < s \leq \infty)$. In that sense the model exhibits sticky prices.[4] Rewriting the state equation as a dynamic demand function results in an objective function given by

$$\max_{q_i} \int_0^\infty e^{-rt}[(a - \sum_{j=1}^{N} q_j(t))q_i(t) - \frac{1}{s}\dot{p}(t)q_i(t) - cq_i(t) - \frac{1}{2}q_i^2(t)]\, dt. \tag{7}$$

In the limiting case $s = \infty$ (instantaneous price adjustment) the payoff of each firm becomes

$$\Pi_i = \int_0^\infty e^{-rt}\Big([a - \sum_{j=1}^{N} q_j(t)]q_i(t) - cq_i(t) - \frac{1}{2}q_i^2(t)\Big)\, dt, \tag{8}$$

which is a repeated Cournot game in its continuous time version.[5]

3 The Premerger Equilibrium

The assumption that the industry equilibrium is identified as a subgame-perfect Cournot equilibrium in Markov strategies means that firms employ price dependent decision rules when maximizing their discounted profits. Thus, changes in the market price stimulate responses by all players that are reflected in their quantity choices. This corresponds to the recognized interdependence present in oligopolistic markets.

Proposition 1 *There exists a Markov perfect equilibrium of the infinitely repeated Cournot game resulting in a market price given by*

$$p^* = \frac{a + N(c - \gamma)}{N + 1 - N\beta}, \tag{9}$$

with β and γ defined as

$$\beta = \frac{N + 1 - \sqrt{N^2 + 2}}{2N - 1}, \qquad \gamma = \frac{c - a\beta - Nc\beta}{N + 1 - (2N - 1)\beta}.$$

[4]In their analysis Fershtman and Kamien (1987) point out that the price dynamics (6) can be viewed as a dynamic demand function that results from rational consumption choices when consumer preferences exhibit habit persistence.

[5]It should be pointed out that instead of deriving the continuous time repated game (8) as the limit of the sticky price model introduced by Fershtman and Kamien (1987), we could use a dynamic Cournot game with adjustment costs and view the repeated game as the limit when the adjustment costs vanish. Both game formulation provide us with the same qualitative results.

The output rates are given by the feedback rule

$$q^* := q_i^* = p^*(1-\beta) + \gamma - c. \tag{10}$$

This results in the symmetric equilibrium output of a firm

$$q^*(N) = (a-c)\frac{N^2 - N + 1 + (N-1)\sqrt{N^2+1}}{N(N^2+2) + (N^2-1)\sqrt{N^2+2}} \tag{11}$$

and the corresponding single period profit

$$\pi^*(N) = (a-c)^2 \frac{2N^4 + 1 + 2N(N^2-1)\sqrt{N^2+2}}{2(N^3 + 2N + (N^2-1)\sqrt{N^2+2})^2}. \tag{12}$$

Proof: The proof of this proposition is a straightforward extension of that given in Fershtman and Kamien (1987). For details see Appendix 1.

The results of Proposition 1 have the following implications. As already pointed out by Fershtman and Kamien (1987) the equilibrium quantities of the infinite horizon repeated game do not coincide with that of the one shot game if firms employ Markov strategies. Firms produce more (and hence market price is lower) in the dynamic game compared to the classical Cournot model. This latter result is an immediate consequence of the Markovian decision rules employed by the firms. In particular, (10) states that firms will increase their ouput with an increase in price. To see why this causes equilibrium quantities to be closer to the competitive equilibrium consider the following scenario. Assume that firm i finds it profitable to reduce its equilibrium quantity. This causes the market price to increase. Given the feedback decision rules of the competitors their optimal response to the increasing price is to increase their equilibrium quantities, thus offsetting firm i's action. This behavior causes all firms in equilibrium to produce beyond the level of simple Cournot quantities.

There is an alternative interpretation to this result which relates the equilibrium outcome of the dynamic game to that of a static conjectural variations equilibrium. Consider the Markovian decision rules (10). They represent a direct relationship between the product price and the quantity supplied by every firm. Further, assume that one of the firms finds it optimal to increase the quantity. This increase in quantity reduces the price and hence immediatly triggers a response of the rival firm to decrease its quantity. In equilibrium, however, this action and reaction pattern as expressed by the price dependent decision rules is taken into account by the rival firms. Therefore when designing an action firm i knows that its rival will react by making an opposite move and hence firm i will take this behavior into account. This, however, corresponds exactly to a conjectural variations model. In fact, Dockner (1992) shows that in a dynamic Cournot model with quadratic adjustment costs the choice of Markovian strategies results in a long run equilibrium price which coincides with the price of a conjectural variations equilibrium of a static Cournot game with identical demand and production cost structures and negative conjectures. Here we prove a similar result for the infinitely repeated Cournot game (5).[6]

[6]See Dockner et al (1994) for a proof of this result in the case of a 2-firm industry ($N = 2$).

Proposition 2 *The stationary Markov perfect equilibrium price* (9) *coincides with a conjectural variations equilibrium price of the static Cournot game*

$$\max_{q_i}\{(a-\sum_{j=1}^{N} q_j)q_i - cq_i - \frac{1}{2}q_i^2\} \tag{13}$$

where all players have constant conjectures given by

$$q_j'(q_i) =: \chi = \frac{2-N-\sqrt{N^2+2}}{N^2-N+1+(N-1)\sqrt{N^2+2}} < 0. \tag{14}$$

Proof: See Appendix 1.

The result presented in Proposition 2 restates the qualitative properties of the Markov perfect equilibrium. As shown in Proposition 1 the equilibrium price is lower and the equilibrium quantities are higher than in the corresponding static Cournot solution implying that the outcome is more competitive. This is exactly what happens in a conjectural variations equilibrium with negative conjectures.

4 Profitability of Horizontal Mergers

Section 3 fully characterizes the dynamic premerger equilibrium. It will be our reference case for analyzing the profitability of a merger. In this section we derive the merger equilibrium and study both its profitability and welfare consequences. Following the approach in most of the existing literature we model a merger as an exogenous change in the number of firms in the industry. In particular, we talk about a horizontal merger of $M+1$ firms in an N-firm industry if $M+1$ firms collude (form a binding coalition) and maximize the sum of the discounted profits. $N-M-1$ firms stay outside the merger, i.e., they behave as dynamic Cournot competitors like in the premerger equilibrium. A comparision of the pre- and the post-merger equilibrium allows us to draw conclusions about the profitability and the welfare of a horizontal merger in a dynamic Cournot market.

In what follows we denote the variables of the merging firms by a bar, whereas the variables of an outsider are as before. Since the merging firms maximize the sum of the discounted profits, the differential game becomes

$$\max_{\bar{q}_1,\cdots,\bar{q}_{M+1}} \Pi^c(N,M) = \max_{\bar{q}_1,\cdots,\bar{q}_{M+1}} \int_0^\infty e^{-rt}[(p-c)\sum_{k=1}^{M+1}\bar{q}_k - \frac{1}{2}\sum_{k=1}^{M+1}\bar{q}_k^2]\,dt \tag{15}$$

$$\max_{q_j} \Pi_j^o(N,M) = \max_{q_j} \int_0^\infty e^{-rt}[(p-c)q_j - \frac{1}{2}q_j^2]\,dt \quad (j = M+2,\ldots,N) \tag{16}$$

subject to

$$\dot{p} = s(a - \sum_{k=1}^{M+1} \bar{q}_k - \sum_{k=M+2}^{N} q_k - p), \tag{17}$$

where Π^c and Π_j^o denote the profit of the coalition and of an outsider firm, respectively.

In Appendix 1 we proof the existence of a Markov-perfect equilibrium for the post-merger game and show that the equilibrium price results in

$$p^* = \frac{a + cN - (M+1)\bar{\gamma} - (N-M-1)\gamma}{N + 1 - (M+1)\bar{\beta} - (N-M-1)\beta}$$

(β, $\bar{\beta}$, γ, $\bar{\gamma}$ are defined in Proposition 3 in Appendix 1). These prices together with the equilibrium quantities of the insiders and the outsiders

$$\begin{aligned} \bar{q}^* &= p^* - c - (\bar{\beta}p^* - \bar{\gamma}) \\ q^* &= p^* - c - (\beta p^* - \gamma) \end{aligned}$$

and the corresponding profits are used to derive the consequences of the pre- and post-merger equilibria for profitability of firms and for the welfare of consumers.[7]

We start our discussion of profitable merger by an extreme case in which all firms in the industry merge to a monopoly. For the monopoly merger the constants $\bar{\beta}$ and $\bar{\gamma}$ are given by

$$\bar{\beta} = \frac{N + 1 - \sqrt{2N+1}}{N} \qquad \text{and} \qquad \bar{\gamma} = \frac{(a + cN)\bar{\beta} - Nc}{N\bar{\beta} - (N+1)},$$

where $\bar{\beta}$ satisfies the stability condition for the equilibrium price (equation (65) in Appendix 1) which together with the output and the profit of a merging firm is given by

$$p^*(N) = \frac{a + cN - n\bar{\gamma}}{N + 1 - n\bar{\beta}} = \frac{a + aN + cN}{1 + 2N} \tag{18}$$

$$\bar{q}^*(N) = \frac{a - c}{1 + 2N} \tag{19}$$

$$\bar{\pi}^*(N) = \frac{(a-c)^2}{2(1+2N)}. \tag{20}$$

The corresponding variables in the static case are identical to those above for the dynamic case, which is to be expected since there are no strategic interactions.

For reference purposes let us write down equilibrium quantities and profits for the static Cournot model as well. Quantities are given by

$$\bar{q}^*_{\text{stat}} = \frac{2(a-c)}{2(N+2) + M(N-M+1)} \tag{21}$$

$$q^*_{\text{stat}} = \frac{(M+2)(a-c)}{2(N+2) + M(N-M+1)} \tag{22}$$

[7] While for constant marginal costs a merger of $M+1$ firms is equivalent to the exit of M firms (cf. Salant et al (1983) and Kwoka (1989)) the case of increasing marginal costs require a separate treatment.

for the insiders and outsiders respctively, which yield the static equilibrium profits

$$\bar{\pi}^*_{\text{stat}} = \frac{2(2M+3)(a-c)^2}{[2(N+2)+M(N-M+1)]^2} \tag{23}$$

$$\pi^*_{\text{stat}} = \frac{3(M+2)^2(a-c)^2}{2[2(N+2)+M(N-M+1)]^2}. \tag{24}$$

After having discussed the case of monopoly merger let us move on to evaluate the profitability of *any* merger. For that reason we consider the equilibrium quantities and profits derived in Proposition 3 in Appendix 1. While in principle this can be done analytically the involved expression do not allow much insights. Therefore we present a numerical analysis instead.

To evaluate the consequences of mergers in a dynamic Cournot market we need to compare the equilibrium values of prices, quantities, and profits prior to and after the merger. Let us start with the simple case in which all firms merge to a monopoly ($M = N - 1$). This requires to compare (19)–(20) to (11)–(12). Clearly, the merger needs to be profitable in that case. Figure 1 shows the differences of the profits (divided by the factor $(a-c)^2$) before and after the merger as functions of N (the dashed line corresponds to the static model). We see that merger to monopoly is always profitable, for the dynamic and the static model. The result corresponds to that in the paper of SSR in which it was found that a merger that consists of more than 80% of the firms in the industry will always be profitable.

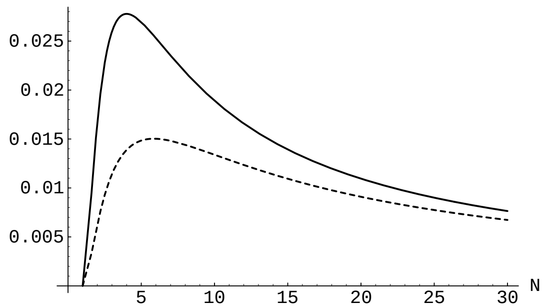

Figure 1: *Differences of premerger and postmerger profits for $M = N - 1$ (i.e. merger to monopoly). The solid line shows the the dynamic case (differences of the one period profits), the dashed line the static case (after dividing by $(a-c)^2$).*

Analysing the profitability of a dynamic merger in cases other than a monopoly merger requires to compare the profits prior to and after the merger. As pointed out in the previous section we do this by means of a numerical analysis. We will report the numerical results for different sizes of the industry resp. different number of merging firms. The numerical values for the outputs and profits of the chosen examples are reported in Appendix 2. We concentrate on two different scenarios. In the first scenario (Tables 1 and 2) we look at a two firm merger in industries with increasing sizes. We start with an industry of size two (in which a merger of two firms is identical to a monopoly merger) and successively increase the number of firms until the industry size becomes 10. In the last case only twenty percent of the firms in the industry merge. We report the pre- and post-merger quantities and profits for both the outsiders and the insiders. We find surprising results. A two firm merger in a dynamic Cournot market is always profitable independent of the size of the industry. Figure 2(a) shows the profit functions (after dividing by $(a-c)^2$), that correspond to the results reported in Table 1. ¿From this graph we see that both the insiders (solid line) and the outsiders (long dashed line) gain from a merger (premerger profits correspond to the short dashed line). Thus, we can argue that in a dynamic model there is an incentive to merge which makes all the firms in an industry better off but at the same time increases the price and hence harms the consumers. While Table 1 reports the results for the dynamic case, Table 2 shows those for the static one. The corresponding graph is given in Figure 2(b).

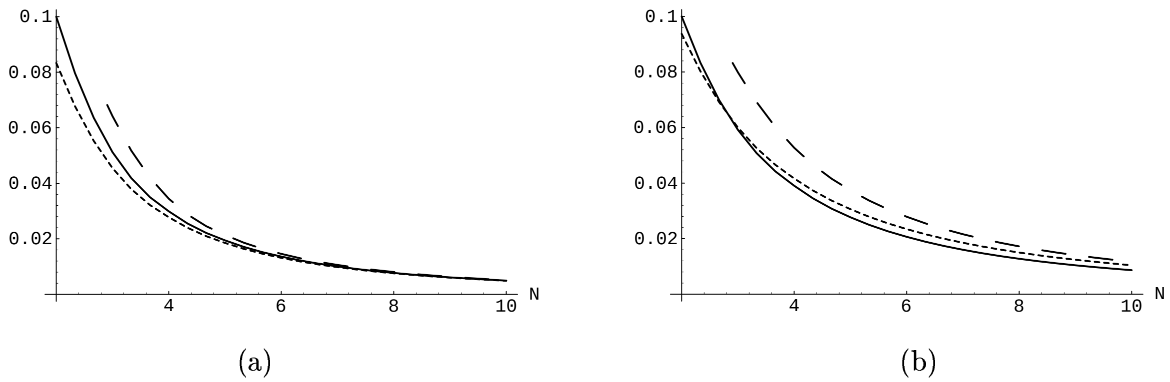

Figure 2: *Premerger (dashed line) and postmerger (solid line for a merging firm, long dashed line for an outsider firm) (one-period) profits in a (a) dynamic, (b) static equilibrium for* $M=1$.

In the second scenario (Tables 3 and 4) we look at an industry of size 10 and study the profitability of mergers with an increasing number of merging firms. We start with a merger of two firms and successively increase the number of insiders. Table 3 reports a by now expected result. Any merger in a ten-firm dynamic industry is profitable. Figure 3(a) depicts the corresponding profits graphically. Again in all the cases both the merging firms and the outsiders benefit from the merger while the benefit is higher the higher the number of merging firms. Table 4 reports the results for the static model which are depicted in Figure 3(b).

The implications of our results are the following. Firstly, the numerical exercises show, that exogenous horizontal mergers are always profitable even though price after the merger

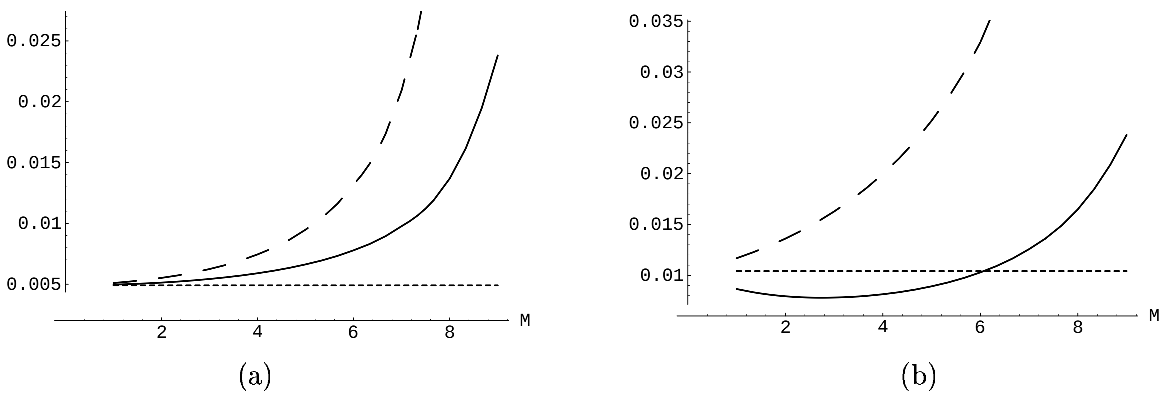

Figure 3: *Premerger (dashed line) and postmerger (solid line for a merging firm, long dashed line for an outsider firm) (one-period) profits in a (a) dynamic, (b) static equilibrium for $N = 10$.*

increases. Secondly, our results demonstrate that the nature of competition (i.e. the anti-competitive force) is crucial for understanding merger activities in an industry. Thirdly, we have demonstrate that the our results are not driven by the qudadratic cost structure assumed for the firms. In general quadratic costs give a benefit to the merged firms because they can spread production on different plants and hence have a cost advantage relative to the outsiders who might produce at a capacity limit already before the merger.

To understand the qualitative properties of our results we need to look at the equilibrium outcome of product market competition in detail. As proven in Proposition 2 the Markov equilibrium of the dynamic Cournot game corresponds to a conjectural variations equilibrium of a corresponding static game with negative conjectures and hence results in an output that is above the Cournot one with an equilibrium price closer to marginal costs. This implies that dynamic competition in the present model resembles many features of Bertrand behaviour. In models where firms act as Bertrand competitors, however, we know that mergers are profitable because the anticompetitive force benefits both the indsiders and the outsiders.

Since we have shown that the Markov perfect equilibrium of the dynamic game corresponds to a conjectural variations equilibrium of a corresponding static game with constant conjectures our results can also be interpreted as an equilibrium foundation of the ones derived by Kwoka (1989). Contrary to Kwoka (1989) our conjectures are not chosen by the firms in an ad hoc fashion, they are the result of equilibrium play when firms use Markovian strategy spaces.

So far we have only dealt with the question of profitability of a merger to the insiders for the case when there are no synergies. Let us now look at the welfare consequences of a merger. For that matter we have to note that the equilibrium price after a merger always increases. This certainly causes consumer surplus to decrease. Whether or not this decrease can be offset by the increase in producer surplus needs to be checked. The numerical analysis is reported in Appendix 2. Tables 5 amd 6 (see also Figure 4) demonstrate that while firms profit from a merger, overall welfare decreases. This is an immediate consequence of the fact that in our model the profitability of the merger results only from anti-competitive forces which benefits the firms in the markets but harms the consumers. Our result can also be understood in the light of the sufficient conditions for welfare increases of mergers derived in Farrell and Shapiro (1990).[8]

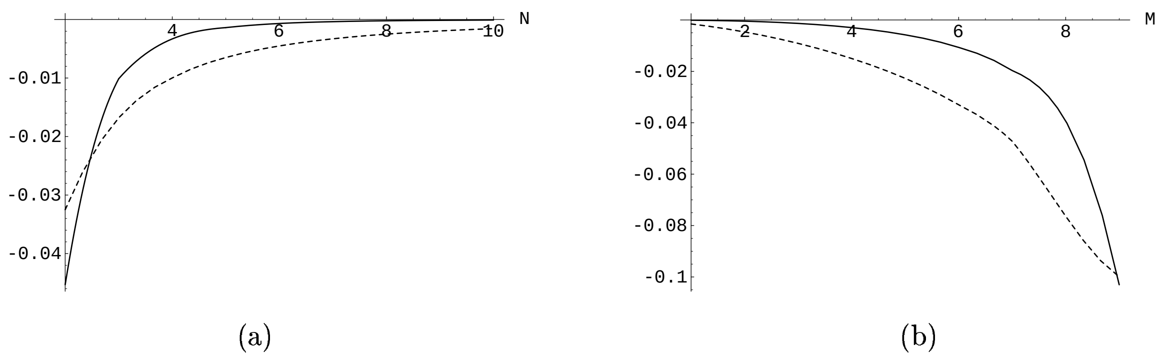

Figure 4: *(a) Changes in welfare for the dynamic (solid line) and the static equilibrium (dashed line) for $M = 1$. (b) Changes in welfare for the dynamic (solid line) and the static equilibrium (dashed line) for $N = 10$.*

Although the results derived in this paper are only of numerical nature, we conjecture, however, that they hold globally and not only for the parameter specifications reported here.

5 Conclusions

In this paper we study the profitabilty of horizontal mergers. In particular, we are interested in the influence of the nature of competition on the profitability of a merger, i.e. under which scenario is the anticompetitive force of a merger strong enough so that both the insiders and the outsiders benefit from an exogenous change in the number of merging units. It turns out that if firms play a dynamic Cournot game, mergers are always profitable independent of the number of merging firms. While this result suggests that when analyzing mergers and their profitability it is important to look at the nature of competition in an industry, a more appropriate approach is to endogenize the merger decision. Recently authors have started to look into this issue both in terms of static as

[8]It can be shown that the sufficient conditions used in Farell and Shapiro (1990) carry over to our dynamic model (i.e. to a conjectural variations equilibrium). However, they are not fulfilled in our case.

well as dynamic models (see, for example, Horn and Persson, 1996). The most prominent example of endogenous merger decisions in a static framework are the papers by Kamien and Zang (1990), (1991), (1993) (see also Gaudet and Salant (1992) for a survey of merger models with an emphasis on endogenous mergers). The most advanced model to analyze merger decisions as the outcome of dynamic firm behaviour is the one recently introduced by Gowrisankaran (1999). His theory is capable of explaining many facts that can be observed in industries with strong merger activities.

Finally, we need to stress a point that is common to all the merger models mentioned in this paper. The profitability results crucially depend on the stability of the cartel that is formed after the merger. Our results indicate that every insider to a meger has an incentive to become an outsider and hence benefit more. This free-rider problem can, however, be easily solved within our dynamic framework. We can allow firms to use trigger strategies in order to sustain cooperation and hence benefit from the merger. On the contrary, a simple one period framework does not allow for such an approach.

6 Appendix 1

Proof of Proposition 1: The proof is carried out for the symmetric interior solutions. We use dynamic programming (see, for example, Dockner et al., 2000). The Bellman equation is given by

$$rV_i(p) = \max_{q_i}\{(p-c)q_i - \frac{1}{2}q_i^2 + V_i' s[a - p - \sum_{j=1}^{N} q_j]\}, \tag{25}$$

where $V_i(p)$ is the optimal value function of firm i. Since the game is symmetric and linear quadratic we conjecture symmetric, quadratic value functions

$$V_i(p) = \frac{K}{2}p^2 - Ep + g, \tag{26}$$

where K, E, and g are constants that need to be determined. Maximizing the right hand side of equation (25) and using the quadratic value function (26) gives

$$sV_i'(p) = s\frac{dV_i(p)}{dp} = s(Kp - E) = p - c - q_i. \tag{27}$$

Substituting this last expression into the Bellman equation yields

$$\begin{aligned} r(\frac{K}{2}p^2 - Ep + g) = \\ &(p-c)(p-c-s(Kp-E)) - \frac{1}{2}(p-c-s(Kp-E))^2 \\ &+s(Kp-E)(a-p-N(p-c)+sN(Kp-E)). \end{aligned} \tag{28}$$

Comparing the coefficients on both sides of the last equation shows that K and E have to satisfy

$$K^2 s^2(2N-1) - K(2(N+1)s + r) + 1 = 0 \tag{29}$$

and

$$E = \frac{-Ksa - NscK + c}{s(N+1) + r + Ks^2(1-2N)}. \tag{30}$$

(27) yields the feedback rules

$$q_i(p) = p(1 - sK) + sE - c. \tag{31}$$

The solutions to equation (29) are given by

$$K = \frac{2s(N+1) + r \pm \sqrt{[2(N+1)s + r]^2 - 4s^2(2N-1)}}{2s^2(2N-1)}. \tag{32}$$

With the decision rules (31) the price equation (6) becomes

$$\dot{p} + ps[N(1-sK) + 1] = s(a + Nc - NsE) \tag{33}$$

which is a linear first order differential equation. A solution to this equation is given by

$$p(t) = p^* + (p_0 - p^*)e^{Dt}, \tag{34}$$

where p^* is the steady state price

$$p^* = \frac{a - NsE + Nc}{1 + N(1 - sK)}. \tag{35}$$

p_0 is the initial price and D is the constant

$$D = s[N(sK - 1) - 1].$$

This constant is only negative, and hence the Markov-perfect equilibrium is globally stable if we choose the negative root of (32). Equations (31) to (35) give us the Markov-perfect equilibrium linear strategies for the differential game (5) and (6) for any finite s. Here, however, we are interested in the limit game (continuous time repeated game) for which the speed of adjustment is infinity, $s = \infty$. This implies from (32)

$$\lim_{s\to\infty} sK = \frac{N + 1 - \sqrt{N^2 + 2}}{2N - 1} = \beta \tag{36}$$

and from (30)

$$\lim_{s\to\infty} sE = \frac{c - a\beta - Nc\beta}{N + 1 - (2N-1)\beta} = \gamma. \tag{37}$$

Moreover, the equilibrium price becomes (because of $\lim_{s\to\infty} D = -\infty$)

$$p(t) = p^* = \frac{a - N\gamma + Nc}{1 + N(1-\beta)}. \tag{38}$$

Given the feedback rule (31) we get

$$q(t) = q^* = p^*(1-\beta) + \gamma - c. \tag{39}$$

This completes the proof. □

Proof of Proposition 2: Maximizing (13) yields

$$\begin{aligned} 0 &= a - 2q_i - \sum_{j=1}^{N} q_j - \sum_{j\neq i} q_j'(q_i)q_i - c \\ &= a - 2q_i - \sum_{j=1}^{N} q_j - \sum_{j\neq i} \chi q_i - c, \end{aligned}$$

which leads to

$$q^{**} := q_i = \frac{a-c}{N+2+(N-1)\chi}. \tag{40}$$

¿From (2) we obtain the corresponding equilibrium price

$$p^{**} = a - \frac{N(a-c)}{N+2+(N-1)\chi}. \tag{41}$$

A straightforward calculation (which we carried out by using *Mathematica*) shows that p^* and p^{**} coincide if and only if χ is given as in (14).[9] Plugging χ into (40) and the corresponding expression for q into (3) yields (11) and (12). □

Proposition 3 *The Markov perfect equilibrium price of the post-merger game* (15) − (17) *with instantaneous price adjustment* ($s = \infty$) *in which* $M+1$ *firms merge and* $N-M-1$ *firms stay outside is given by*

$$p^* = \frac{a + cN - (M+1)\bar{\gamma} - (N-M-1)\gamma}{N+1-(M+1)\bar{\beta} - (N-M-1)\beta}, \tag{42}$$

[9] For the general case of finite price adjustment speed $s < \infty$ the conjectures are given by

$$\chi = \frac{-r - (N-1)s(1-sK)}{r + Ns - (N-1)s^2K},$$

where K is the negative root in (32).

where $\bar\beta$, β, $\bar\gamma$, γ are the roots of equations (61) – (64) *below such that* (65) *holds and the single period profits of all firms are strictly positive. The symmetric equilibrium outputs are given by*

$$\bar q^* = p^* - c - (\bar\beta p^* - \bar\gamma) \tag{43}$$
$$q^* = p^* - c - (\beta p^* - \gamma). \tag{44}$$

Proof: We proceed in analogy to the proof of Proposition 1, determining the symmetric interior solutions.

The Bellman equations now are given by

$$rV^c(p) = \max_{\bar q_1,\cdots,\bar q_{M+1}}[(p-c)\sum_{k=1}^{M+1}\bar q_k - \frac{1}{2}\sum_{k=1}^{M+1}\bar q_k^2 + (V^c)'\dot p] \tag{45}$$

resp.

$$rV_j^o(p) = \max_{q_j}[(p-c)q_j - \frac{1}{2}q_j^2 + (V_j^o)'\dot p] \qquad (j = M+2,\ldots,N). \tag{46}$$

Maximizing the right hand sides of (45) and (46) and assuming quadratic value functions

$$V^c(p) = (M+1)[\frac{\bar K}{2}p^2 - \bar E p + \bar g] \tag{47}$$
$$V_j^o(p) = \frac{K}{2}p^2 - Ep + g \qquad (j = M+2,\ldots,N) \tag{48}$$

gives

$$\bar q := \bar q_i = p - c - s(\bar K p - \bar E) \qquad i = 1,\ldots,M+1 \tag{49}$$
$$q := q_j = p - c - s(Kp - E) \qquad j = M+2,\ldots,N \tag{50}$$

from which we obtain, by substituting into the Bellman equations,

$$\begin{aligned} r(\frac{\bar K}{2}p^2 - \bar E p + \bar g) = \\ (p-c)(p-c-s(\bar K p - \bar E))(M+1) - \frac{1}{2}(p-c-s(\bar K p - \bar E))^2(M+1) \\ +s(\bar K p - \bar E)[a - p - (M+1)(p-c-s(\bar K p - \bar E)) \\ - (N-M-1)(p-c-s(Kp-E)] \end{aligned} \tag{51}$$

$$\begin{aligned} r(\frac{K}{2}p^2 - Ep + g) = \\ (p-c)(p-c-s(Kp-E)) - \frac{1}{2}(p-c-s(Kp-E))^2 \\ +s(Kp-E)[a - p - (M+1)(p-c-s(\bar K p - \bar E)) \\ - (N-M-1)(p-c-s(Kp-E))]. \end{aligned} \tag{52}$$

Comparing coefficients yields that $\bar{K}$, K, $\bar{E}$, E have to fulfill the following equations

$$\begin{aligned}
(M+1)s^2\bar{K}^2 - (2s(N+1)+r)\bar{K} + M + 1 + 2(N-M-1)s^2\bar{K}K &= 0 \quad (53)\\
(2N-2M-3)s^2K^2 - (2s(N+1)+r)K + 1 + 2(M+1)^2s^2K\bar{K} &= 0 \quad (54)\\
[s(N+1)+r) - (M+1)s^2\bar{K} - (N-M-1)s^2K]\bar{E} - (N-M-1)s^2\bar{K}E & \\
+(a+cN)s\bar{K} - (M+1)c &= 0 \quad (55)\\
[(s(N+1)+r) - (2N-2M-3)s^2K - (M+1)s^2\bar{K}]E - (M+1)s^2K\bar{E} & \\
+(a+cN)s\bar{K} - c &= 0. \quad (56)
\end{aligned}$$

The price equation (6) becomes

$$\begin{aligned}
\dot{p} &= s\{p[-(N+1) + (M+1)s\bar{K} + (N-M-1)sK] + \\
& \quad a + cN - (M+1)s\bar{E} - (N-M-1)sE\}. \qquad (57)
\end{aligned}$$

The solution is given as in (34) with the steady state price

$$p^* = \frac{a + cN - (M+1)s\bar{E} - (N-M-1)sE}{N + 1 - (M+1)s\bar{K} - (N-M-1)sK} \qquad (58)$$

and

$$D = s[-(N+1) + (M+1)s\bar{K} + (N-M-1)sK]. \qquad (59)$$

In the limiting case $s = \infty$ the equilibrium price becomes

$$p^* = \frac{a + cN - (M+1)\bar{\gamma} - (N-M-1)\gamma}{N + 1 - (M+1)\bar{\beta} - (N-M-1)\beta}, \qquad (60)$$

where the parameters

$$\bar{\beta} := \lim_{s\to\infty} s\bar{K}, \quad \beta := \lim_{s\to\infty} sK, \quad \bar{\gamma} := \lim_{s\to\infty} s\bar{E}, \quad \gamma := \lim_{s\to\infty} sE$$

have to satisfy the equations

$$\begin{aligned}
&(M+1)^2(2N-2M-1)\bar{\beta}^4 - 4(N+1)(M+1)(N-M)\bar{\beta}^3 + \\
&\quad 2[2(N+1)^2 + (M+1)^2 - 2(N-M-1)^2]\bar{\beta}^2 + \\
&\quad 4(N+1)(M+1)(N-M-2)\bar{\beta} - (M+1)^2(2N-2M-3) = 0 \qquad (61)
\end{aligned}$$

$$\begin{aligned}
&(2N-2M-3)(2N-2M-1)\beta^4 - 8(N+1)(N-M-1)\beta^3 + \\
&\quad 2[2(N+1)^2 - 2(M+1)^2 + 1]\beta^2 - 1 = 0 \qquad (62)
\end{aligned}$$

$$\begin{aligned}
(N-M-1)\bar{\beta}\gamma + [(M+1)\bar{\beta} + (N-M-1)\beta - (N+1)]\bar{\gamma} &= \\
(a+cN)\bar{\beta} - (M+1)c & \qquad (63)\\
(M+1)\beta\bar{\gamma} + [(2N-2M-3)\beta + (M+1)\bar{\beta} - (N+1)]\gamma &= \\
(a+cN)\beta - c. & \qquad (64)
\end{aligned}$$

p^* is a stable equilibrium iff

$$-(N+1) + (M+1)\bar{\beta} + (N-M-1)\beta < 0 \qquad (65)$$

in which case $\lim_{s\to\infty} D \to -\infty$. □

7 Appendix 2: Numerical Analysis

We denote pre-merger resp. post-merger output and profit as[10]

$$\begin{aligned}
q^*(N) &= (a-c)\cdot q_{\text{dyn}}^{\text{pre}}(N) \\
\pi^*(N) &= (a-c)^2\cdot \pi_{\text{dyn}}^{\text{pre}}(N) \\
q_{\text{stat}}^*(N) &= (a-c)\cdot q_{\text{stat}}^{\text{pre}}(N) \\
\pi_{\text{stat}}^*(N) &= (a-c)^2\cdot \pi_{\text{stat}}^{\text{pre}}(N)
\end{aligned}$$

resp.

$$\begin{aligned}
\bar{q}^*(N,M) &= (a-c)\cdot \bar{q}_{\text{dyn}}^{\text{post}}(N,M) \\
q^*(N,M) &= (a-c)\cdot q_{\text{dyn}}^{\text{post}}(N,M) \\
\bar{\pi}^*(N,M) &= (a-c)^2\cdot \bar{\pi}_{\text{dyn}}^{\text{post}}(N,M) \\
\pi^*(N,M) &= (a-c)^2\cdot \pi_{\text{dyn}}^{\text{post}}(N,M) \\
\bar{q}_{\text{stat}}^*(N,M) &= (a-c)\cdot \bar{q}_{\text{stat}}^{\text{post}}(N,M) \\
q_{\text{stat}}^*(N,M) &= (a-c)\cdot q_{\text{stat}}^{\text{post}}(N,M) \\
\bar{\pi}_{\text{stat}}^*(N,M) &= (a-c)^2\cdot \bar{\pi}_{\text{stat}}^{\text{post}}(N,M) \\
\pi_{\text{stat}}^*(N,M) &= (a-c)^2\cdot \pi_{\text{stat}}^{\text{post}}(N,M)
\end{aligned}$$

[10] We carried out our computations by using the program *Mathematica*.

Tables 1 and 2 show the values when 2 firms merge ($M = 1$) for $N = 2, \ldots, 10$ (cf. Fig. 2(a),(b)).

N	$q_{\text{dyn}}^{\text{pre}}(N)$	$\pi_{\text{dyn}}^{\text{pre}}(N)$	$\bar{q}_{\text{dyn}}^{\text{post}}(N,1)$	$q_{\text{dyn}}^{\text{post}}(N,1)$	$\bar{\pi}_{\text{dyn}}^{\text{post}}(N,1)$	$\pi_{\text{dyn}}^{\text{post}}(N,1)$
2	0.28165	0.083333	0.2	—	0.1	—
3	0.22900	0.045455	0.17999	0.26558	0.051196	0.064177
4	0.18968	0.027778	0.15649	0.20881	0.029913	0.034452
5	0.16089	0.018519	0.13692	0.17189	0.019446	0.021407
6	0.13932	0.013158	0.12122	0.14616	0.013615	0.014593
7	0.12268	0.009804	0.10855	0.12721	0.010052	0.010593
8	0.10951	0.007576	0.09818	0.11265	0.007721	0.008044
9	0.09885	0.006024	0.08957	0.10112	0.006115	0.006319
10	0.09005	0.004902	0.08232	0.09174	0.004961	0.005097

Table 1

N	$q_{\text{stat}}^{\text{pre}}(N)$	$q_{\text{stat}}^{\text{pre}}(N)$	$\bar{q}_{\text{stat}}^{\text{post}}(N,1)$	$q_{\text{stat}}^{\text{post}}(N,1)$	$\bar{\pi}_{\text{stat}}^{\text{post}}(N,1)$	$\pi_{\text{stat}}^{\text{post}}(N,1)$
2	0.25	0.09375	0.2	—	0.1	—
3	0.2	0.06	0.15385	0.23077	0.059172	0.079882
4	0.16667	0.041667	0.125	0.1875	0.039063	0.052734
5	0.14286	0.030612	0.10526	0.15790	0.027701	0.037396
6	0.125	0.023438	0.09091	0.13636	0.020661	0.027892
7	0.11111	0.01852	0.08	0.12	0.016	0.0216
8	0.1	0.015	0.07143	0.10714	0.012755	0.017219
9	0.09091	0.012397	0.06452	0.09677	0.010406	0.014048
10	0.08333	0.010417	0.05882	0.08824	0.008651	0.011678

Table 2

Tables 3 and 4 show the post-merger values for a 10-firm industry ($N = 10$) as functions of the number of merging firms $M = 1, \ldots, 9$ (c.f. Fig. 3(a),(b)). The pre-merger values are given in the first two columns of the last rows of Tables 1 and 2.

M	$\bar{q}_{\text{dyn}}^{\text{post}}(10, M)$	$q_{\text{dyn}}^{\text{post}}(10, M)$	$\bar{\pi}_{\text{dyn}}^{\text{post}}(10, M)$	$\pi_{\text{dyn}}^{\text{post}}(10, M)$
1	0.08232	0.09174	0.004961	0.005097
2	0.07584	0.09528	0.005129	0.005517
3	0.07033	0.10106	0.005426	0.006245
4	0.06558	0.10988	0.005898	0.007448
5	0.06143	0.12320	0.006627	0.009485
6	0.05777	0.14397	0.007787	0.013202
7	0.05448	0.17877	0.009773	0.020959
8	0.05136	0.24553	0.013689	0.041597
9	0.04762	—	0.023810	—

Table 3

M	$\bar{q}_{\text{stat}}^{\text{post}}(10, M)$	$q_{\text{stat}}^{\text{post}}(10, M)$	$\bar{\pi}_{\text{stat}}^{\text{post}}(10, M)$	$\pi_{\text{stat}}^{\text{post}}(10, M)$
1	0.05882	0.08824	0.008651	0.011678
2	0.04762	0.09524	0.007937	0.013605
3	0.04167	0.10417	0.007813	0.016276
4	0.03846	0.11539	0.008136	0.019970
5	0.03704	0.12963	0.008916	0.025206
6	0.03704	0.14815	0.010288	0.032922
7	0.03846	0.17308	0.012574	0.044933
8	0.04167	0.20833	0.016493	0.056424
9	0.04762	—	0.023810	—

Table 4

In our numerical examples $\bar{\beta}$ and β are the second smallest roots of (61) and (62). (As pointed out in Proposition 3, $\bar{\beta}$ and β have to be chosen such that the stability condition (65) holds and the single period profit of all firms are > 0.)

Welfare analysis

The overall welfare W is given as the sum of producers' surplus (producers' profits) and consumers' surplus. Since we assume a linear demand function consumers' surplus is given by $\frac{1}{2}Q^2$, where $Q = \sum_i q_i$. Thus the change in welfare ΔW caused by a merger of $M + 1$ firms in an N-firm industry is given by

$$\Delta W = (M+1)\bar{\pi}^{\text{post}} + (N-M-1)\pi^{\text{post}} - N\pi^{\text{pre}}$$
$$-\frac{1}{2}[\underbrace{((M+1)\bar{q}^{\text{post}} + (N-M-1)q^{\text{post}})^2}_{(Q^{\text{post}})^2} - \underbrace{N^2(q^{\text{pre}})^2}_{(Q^{\text{pre}})^2}].$$

Tables 5 and 6 show the changes in welfare when 2 firms merge ($M = 1$) for $N = 2, \ldots, 10$ (cf. Fig. 4). $Q = \sum_i q_i$ denotes industry output.

dynamic competition:

N	$Q_{\text{dyn}}^{\text{pre}}$	$Q_{\text{dyn}}^{\text{post}}$	producer surplus	consumer surplus	welfare gain
2	0.5633	0.4	0.033333	−0.078653	−0.045320
3	0.68701	0.62556	0.030206	−0.040328	−0.010123
4	0.75872	0.73060	0.017619	−0.020934	−0.003315
5	0.80446	0.78952	0.010520	−0.011905	−0.001384
6	0.83590	0.82708	0.006654	−0.007334	−0.000679
7	0.85875	0.85312	0.004442	−0.004815	−0.000373
8	0.87606	0.87227	0.003100	−0.003318	−0.000218
9	0.88963	0.88695	0.002245	−0.002388	−0.000142
10	0.90054	0.89858	0.001678	−0.001766	−0.000088

Table 5

static competition:

N	$Q_{\text{stat}}^{\text{pre}}$	$Q_{\text{stat}}^{\text{post}}$	producer surplus	consumer surplus	welfare gain
2	0.5	0.4	0.0125	−0.045	−0.0325
3	0.6	0.53846	0.018225	−0.035030	−0.016805
4	0.66667	0.625	0.016927	−0.026911	−0.009984
5	0.71429	0.68421	0.014529	−0.021029	−0.006500
6	0.75	0.72728	0.012267	−0.016785	−0.004518
7	0.77778	0.76	0.010371	−0.013669	−0.003298
8	0.8	0.78572	0.008826	−0.011326	−0.002500
9	0.81818	0.80645	0.007577	−0.009529	−0.001952
10	0.83333	0.82353	0.006560	−0.008119	−0.001559

Table 6

Tables 7 and 8 show the changes in welfare for a 10-firm industry ($N = 10$) as functions of the number of merging firms $M = 1, \ldots, 9$ (c.f. Fig. 5)).

dynamic competition ($Q_{\rm dyn} = 0.90054$):

M	$Q_{\rm dyn}^{\rm post}$	producer surplus	consumer surplus	welfare gain
1	0.89886	0.001675	−0.001766	−0.000091
2	0.89445	0.004989	−0.005463	−0.000474
3	0.88768	0.010155	−0.011499	−0.001345
4	0.87728	0.017709	−0.020680	−0.002970
5	0.86141	0.028681	−0.034468	−0.005787
6	0.83631	0.045095	−0.055775	−0.010680
7	0.79338	0.071079	−0.090763	−0.019683
8	0.70768	0.115775	−0.155082	−0.039307
9	0.47619	0.189075	−0.292107	−0.103031

Table 7

static competition ($Q_{\rm stat} = 0.83333$):

M	$Q_{\rm stat}^{\rm post}$	producer surplus	consumer surplus	welfare gain
1	0.82353	0.006560	−0.008119	−0.001559
2	0.80952	0.014881	−0.019555	−0.004674
3	0.79167	0.024738	−0.033850	−0.009112
4	0.76923	0.036365	−0.051360	−0.014995
5	0.74074	0.050154	−0.072870	−0.022717
6	0.70370	0.066615	−0.099620	−0.033005
7	0.65385	0.086292	−0.133462	−0.047170
8	0.58333	0.100694	−0.177081	−0.076386
9	0.47619	0.133928	−0.233841	−0.099913

Table 8

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