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Abstract

This paper analyzes endogenous merger formation in oligopolistic markets where firms have different unit production costs. We reformulate the merger model, introduced by *Barros* (1998), by employing the core as cooperative equilibrium concept. We show that, depending on the size asymmetry in the pre-merger market, this alternative solution concept predicts a different post-merger market structure. For intermediate size differences, it is not the most efficient firm that is generally involved in the merger but the least efficient firm. Additionally, we present a welfare analysis which shows that under a wide range of size asymmetries, endogenous merger formation has a welfare improving net effect.

Keywords: Asymmetric endogenous mergers; Coalition formation

JEL classification: C71, G34, L41

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1 Introduction

Since the seminal work by *Salant, Switzer, Reynolds* (1983), the relationship between pre-merger market structure and merger formation has attracted a great deal of attention in the Industrial-Organization literature. One of the most interesting recent contributions to this literature has been provided by *Barros* (1998). He analyzes a stylized triopoly model in order to demonstrate "... the basic economic intuition about the relationship between initial market concentration and size asymmetry of merger participants" (*Barros* 1998, 114). By extending the symmetric *Salant-Switzer-Reynolds* model, he shows that the effects of a merger on the firms' profits and, hence, the merger formation, crucially depend on the initial size asymmetry of the competitiors. *Barros* concludes that the most efficient firm always participates if cost differences are sufficiently high to induce a merger. It turns out, however, that this result is sensitive to his choice of stability conditions.[1]

In this paper, we consider *Barros*' setup but employ the core concept of cooperative game theory as introduced to the merger literature by *Horn*, *Persson* (2001a) in order to derive the endogenous merger formation. It will be shown that, in contrast to *Barros*' results, it is the least efficient firm that is typically involved in a merger if size differences are moderate. Hence, application of the core yields a new qualitative interpretation of endogenous mergers in asymmetric markets. Our results suggest that efficiency gains from asymmetric mergers are the driving force behind the merger formation in oligopolistic markets.

2 The Model

Building on the oligopoly model by *Barros* (1998), we consider a homogeneous market with the inverse demand function $p = 1 - Q$. Initially, there are three firms using different technologies characterized by the constant unit costs $c_1 < c_2 < c_3 < 1$. Differences in these costs are assumed to be given by

$$c_1 + 2\Delta = c_2 + \Delta = c_3,$$

where the parameter $\Delta > 0$ is an indicator of asymmetry and, hence, of market concentration as measured for example by the Herfindahl index. Efficiency gains

[1] *Faulí-Oller* (2002) also analyzes mergers of asymmetric firms. However, he focuses on the effect of the concavity of demand on the profitability and the welfare effect of mergers.

realized by mergers are reflected by the assumption that merged firms use the technology of the most efficient participant. Furthermore, we assume that mergers which result in a monopoly are prohibited by antitrust laws. Hence, starting with a pre-merger market structure $M^0 = \{1, 2, 3\}$, three mergers are possible, leading to the post-merger market structures $M^A = \{12, 3\}$, $M^B = \{13, 2\}$, and $M^C = \{1, 23\}$.

The merger game consists of two stages. In the first stage, the firm owners decide on whether to merge at all and if, which partner to choose. This coalition formation determines the post-merger market structure of the second stage in which the remaining competitors play a Cournot quantity game.

2.1 The Production Stage

In the production stage, we analyze quantity competition with two or three firms in the market, depending on the previous merger decisions. Defining $\delta \equiv \Delta/(1 - c_1)$ and $\Gamma \equiv (1 - c_1)^2/144$, profits of firms $k = 1, 2, 3$ in the triopoly case amount to

$$\pi_1^0 = 9\,\Gamma(1 + 3\delta)^2$$
$$\pi_2^0 = 9\,\Gamma(1 - \delta)^2$$
$$\pi_3^0 = 9\,\Gamma(1 - 5\delta)^2.$$

In the cases of the three possible duopoly market structures, profits of firms (coalitions) $k = 1, 2, 3, 12, 13, 23$ are given by

$$\pi_{12}^A = 16\,\Gamma(1 + 2\delta)^2$$
$$\pi_3^A = 16\,\Gamma(1 - 4\delta)^2$$
$$\pi_{13}^B = \pi_1^C = 16\,\Gamma(1 + \delta)^2$$
$$\pi_2^B = \pi_{23}^C = 16\,\Gamma(1 - 2\delta)^2.$$

To ensure non-negative outputs and profits of all firms, we assume $\delta \leq 0.2$ throughout. In order to identify the conditions under which each merger is carried out, it is necessary to introduce criteria which compare the outcomes of one market structure to another.

2.2 The Merger Stage

Barros (1998) imposes two stability conditions on mergers. The first is the participation constraint requiring that the profits of merging firms must be higher than the sum of the participants' pre-merger profits. The second constraint implies that the firm external to the merger cannot offer a more profitable alternative to either of the firms participating in the merger. It turns out, however, that more than one merger can be sustained for a given value of size asymmetry δ. Therefore, *Barros* imposes an additional criterion in order to determine which merger will occur. This criterion is the highest incremental profit of the two participants involved in the merger. Using this solution concept, *Barros* derives the following proposition:

(i) for $\delta \in [0, 0.034]$, there is no merger. $M^0 = \{1, 2, 3\}$ is therefore the pre- as well as post-merger market structure.

(ii) for $\delta \in (0.034, 0.152]$, there is a merger between firm 1 and 3, leading to the post-merger market structure $M^B = \{13, 2\}$.

(iii) for $\delta \in (0.152, 0.2]$, there is a merger between firm 1 and 2, resulting in the post-merger market structure $M^A = \{12, 3\}$.

In all merger deals in which the owners of firms can freely communicate and are able to write binding contracts, it seems to be adequate to view the owners as participating in some form of bargaining over the coalition formation. Recently, *Horn*, *Persson* (2001a) proposed a model of endogenous mergers employing the core on coalition formation. This equilibrium concept allows for a free division of the gains between the participants resulting from bargaining. In a companion paper, *Horn*, *Persson* (2001b) use this approach in order to analyze a symmetric (international) oligopoly. The present paper shows that the core concept can also be constructively applied to the asymmetric model analyzed by *Barros* (1998).

In order to derive the equilibrium post-merger market structures, a relation that compares the outcome of one market structure with another has to be defined. Following *Horn*, *Persson* (2001a), we make use of a binary dominance relation. According to this relation, market structure M^i is dominated by market structure $M^j,\ i, j = O, A, B, C;\ i \neq j$, if the owners, who have the power to enforce either of the two market structures, prefer M^j over M^i. The group of "decisive" owners who are able to determine the ranking of the two market structures is defined in the following way. Let $\mathcal{H}^i$ be a subset of the set of firms (coalitions) in M^i, and let $\mathcal{O}(\mathcal{H}^i)$ be the set of owners participating in the firms in $\mathcal{H}^i$. Analogously, let

$\mathcal{H}^j$ be a subset of firms with owners $\mathcal{O}(\mathcal{H}^j)$ from M^j. Then, a group of decisive owners, $\mathcal{D}^{ij}$, with respect to the two alternative market structures M^i and M^j and the corresponding subsets of firms $\mathcal{H}^i$ and $\mathcal{H}^j$ in possession of these owners is given by:

(i) $\mathcal{D}^{ij} = \mathcal{O}(\mathcal{H}^i) = \mathcal{O}(\mathcal{H}^j) \neq \emptyset$

(ii) $\mathcal{H}^i \cap \mathcal{H}^j = \emptyset$

(iii) $\nexists \mathcal{D} \subset \mathcal{D}^{ij} | \mathcal{D}$ fulfills (i) and (ii).

On the basis of this concept of a group of decisive owners, it is possible to define the binary dominance relation. Market structure M^j dominates market structure M^i via $\mathcal{D}^{ij}$, i.e. $M^i \prec M^j$, if and only if the combined profits of the group of decisive owners is larger in M^j than in M^i, i.e.[2]

$$\sum_{k \in \mathcal{H}^i} \pi_k^i < \sum_{k \in \mathcal{H}^j} \pi_k^j.$$

Having defined the dominance relation that ranks any pair of market structures, the set of equilibrium market structures is given by the core, i.e.

$$\mathcal{M} \setminus \{M^i \in \mathcal{M} |\ M^j \in \mathcal{M} \text{ such that } M^i \prec M^j\}.$$

Accordingly, all dominated market structures are excluded from the set of equilibrium market structures. In many applications in economic theory, the core is empty. Under such circumstances, we would not be able to predict an equilibrium post-merger market structure. Fortunately, this problem does not arise in the considered oligopoly model.

3 Endogenous Merger Formation

In order to derive the endogenous merger formation, the dominance relation stated above has to be analyzed for all market structures and decisive groups. The results of these comparisons are summarized in Figure 1. It shows that endogenous merger formation crucially depends on the size asymmetry δ and, hence, on market concentration. Our findings are:

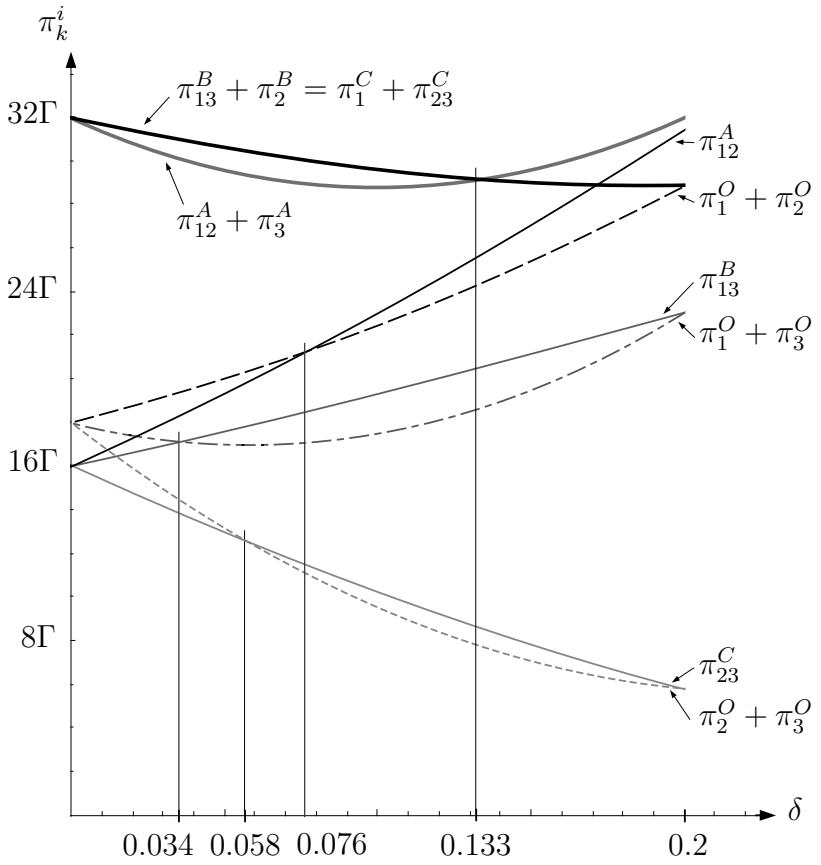
[2] Since in this Cournot triopoly the outsiders of a merger to duopoly are not decisive, a situation with two groups of decisive owners cannot arise.

(i) for $\delta \in [0, 0.034]$, there is no merger. The market structure $M^0 = \{1, 2, 3\}$ remains unchanged.

(ii) for $\delta \in (0.034, 0.058]$, there is a merger between firm 1 and 3. $M^B = \{13, 2\}$ is the corresponding post-merger market structure. For $\delta \in (0.058, 0.133]$, there is a merger between firm 1 and 3 or between firm 2 and 3. The two undominated market structures $M^B = \{13, 2\}$ and $M^C = \{1, 23\}$ correspond to the core.

(iii) for $\delta \in (0.133, 0.2]$, there is a merger between firm 1 and 2, leading to the market structure $M^A = \{12, 3\}$.

Figure 1: Profit Sums of the Decisive Groups in the Different Market Structures



$\pi_1^O = 9\,\Gamma(1+3\delta)^2,\ \pi_2^O = 9\,\Gamma(1-\delta)^2,\ \pi_3^O = 9\,\Gamma(1-5\delta)^2,$
$\pi_1^O + \pi_2^O = 18\,\Gamma(1+2\delta+5\delta^2),$
$\pi_1^O + \pi_3^O = 18\,\Gamma(1-2\delta+17\delta^2),$
$\pi_2^O + \pi_3^O = 18\,\Gamma(1-6\delta+13\delta^2);$
$\pi_{12}^A = 16\,\Gamma(1+2\delta)^2,\ \pi_{12}^A + \pi_3^A = 16\,\Gamma(2-2\delta+5\delta^2),$
$\pi_{13}^B = 16\,\Gamma(1+\delta)^2,$
$\pi_{23}^C = 16\,\Gamma(1-2\delta)^2,$
$\pi_{13}^B + \pi_2^B = \pi_1^C + \pi_{23}^C = 32\,\Gamma(1-2\delta+10\delta^2)$

A comparison of the predicted merger patterns resulting from the solution concept used by *Barros* and the one used by us shows some remarkable differences. Of course, conclusion (i) is identical. For small size differences, it is not individually rational for a firm to engage in a merger. The output reduction of the merged firm is overcompensated by an increased production of the outsider if cost asymmetries are small. This case corresponds to the more general result derived by *Salant, Switzer, Reynolds* (1983) that in a symmetric Cournot oligopoly with linear demand and cost functions, mergers are unprofitable unless they involve at least 80% of the firms in the market. Conclusion (iii) predicts the same equilibrium market structure as in the *Barros* formulation, however, for a wider range of cost differences δ. With a larger size asymmetry, the output produced by firm 3 is very small. A merger with this inefficient firm would not induce a sufficiently large output reduction to make the merger profitable for the participants. Therefore, firm 3 is not involved in an endogenous merger formation. An important difference appears in conclusion (ii). *Barros*' solution predicts a merger between firms 1 and 3 suggesting that it is the most efficient firm which is generally involved in a merger if it occurs at all. Our results indicate that there is only a small range of moderate size asymmetries in which this merger formation proves to be the only equilibrium. Using the core concept, we derive an additional range of cost differences with two undominated equilibrium market structures resulting from a merged entity consisting of firms 1 and 3 or firms 2 and 3. Under these circumstances it is therefore not the most efficient firm 1 but the least efficient firm 3 which participates in a merger. As long as firm 3 produces a considerable amount of output in the pre-merger market, the efficiency gain of a merger with this firm is the driving force behind the merger formation.

4 Welfare Analysis

In order to evaluate the welfare effect of the predicted merger activities, we have to compare the social welfare

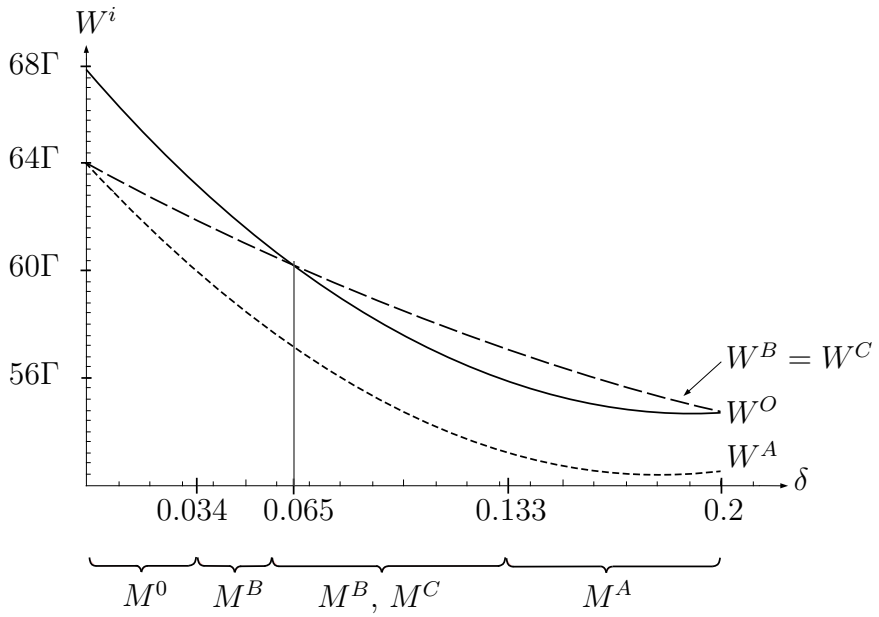
$$W^i = \sum_k \pi_k^i + CS^i.$$

for the pre-merger triopoly $i = O$ with the corresponding equilibrium post-merger market structures $i = A, B, C$. Consumer surplus $CS^i = (1 - p^i)^2/2$ is given by

$$CS^0 = 40.5\,\Gamma(1-\delta)^2$$
$$CS^A = 32\,\Gamma(1-\delta)^2$$
$$CS^B = CS^C = 8\,\Gamma(2-\delta)^2.$$

The corresponding expressions for the welfare in the different market structures are summarized in Figure 2.

Figure 2: Welfare in the Equilibrium Market Structures



$$W^O = 4.5\,\Gamma(15 - 30\delta + 79\delta^2),$$
$$W^A = 8\,\Gamma(8 - 8\delta + 11\delta^2),$$
$$W^B = W^C = 32\,\Gamma(2 - 4\delta + 11\delta^2)$$

It can be seen that for a wide range of size asymmetries $\delta \in (0.065, 0.133]$ the endogenous merger formation improves welfare. This is due to the fact that the least efficient firm participates in a merger to the market structures M^B and M^C. In both cases, firms produce with the most efficient technologies. The resulting efficiency gain from lower post-merger production costs outweighs the output contraction that is due to increased market power. This result at the same time disproves *Barros* (1998, 116), who claims that "... comparing any of the post-merger welfare values to the ex-ante welfare, any of the mergers entails a welfare loss, due to the reduction in competition." Only if initially firms do not differ widely in their efficiency, $\delta \in (0.034, 0.065]$, does the resulting merger to M^B or M^C cause a welfare loss compared

to the pre-merger situation. In this case, the gain resulting from replacing the least efficient technology by a more efficient one in the production of part of the total quantity in the market is too small and cannot compensate the output reduction by the merged firm. If the differences are even smaller, $\delta \in [0, 0.034]$, no merger takes place. As a consequence of the low efficiency gains that could be realized, a merger is both privately and socially undesirable. However, if initial size differences are high, the least efficient firm 3 remains an independent, high cost competitor in the post-merger market. In this case, the gain from replacing the intermediate and not the least efficient technology (as would be the case by a merger to M^B or M^C) cannot compensate for the reduction in the overall quantity caused by the output contraction of the merged firm 12. Social welfare is therefore reduced by the merger to the market structure M^A.

In sum, there are two conclusions from the comparison of welfare in the different post-merger market structures. Firstly, a merger increases welfare only if the pre-merger size differences are significant. Secondly, a merger without participation of the least efficient firm is never welfare increasing.

5 Conclusion

The model analyzed in this paper emphasizes the importance of cost asymmetries in the process of merger formation. Instead of the unconvincing stability conditions suggested by *Barros* (1998), who assumes that the merger with the highest incremental gain for the participants is realized, we use the core as the equilibrium concept in order to derive the endogenous merger formation. In our view, this cooperative equilibrium concept best reflects the bargaining process leading to a merger contract and the resulting free division of the profits of the merged entity amongst the owners of the previously independent firms.

In our stylized triopoly market, mergers are undertaken only if technological differences between the firms and hence potential synergies are not negligible. If these differences are severe, participation of a high-cost firm in a merger is not privately optimal. This firm initially produces a small quantity. Hence, the efficiency gains from its inclusion in a merger are low. The differences in the prediction of the model by *Barros* (1998) and the analysis presented in this paper pertains to markets with intermediate size differences of the firms. In *Barros*' model, it is the most efficient firm that is involved in all mergers, whereas the application of the core shows that in such markets it is the participation of the least efficient firm and the resulting replacement of its technology that drives the merger decisions.

Moreover, our welfare analysis showed that the initial market structure is both privately and socially optimal if cost differences are negligible. If cost asymmetries fall in an intermediate range, mergers to a duopoly that replaces the least efficient technology yield the highest welfare. At the same time, these mergers are the most profitable for the participating firms. Only if the initial size differences of the firms are either rather low or severe, does the privately optimal merger lead to a reduction in welfare compared to the pre-merger triopoly as in these cases the resulting output reduction by the merging firms dominates the efficiency gain.

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