

Mergers, Divestitures and Industry Reorganization

Larry Qiu and Wen Zhou*

October 6, 2010

Abstract

This paper reports a study of how an industry reorganizes through firms' costly restructuring, which can be expansion through a merger or contraction through a divestiture. Restructuring is shown to be profitable only when market size is moderate. An industry's reorganization can therefore be attributed to a positive or negative demand shock that changes the market's size. Profitability, however, is neither necessary nor sufficient for a restructuring to take place, as the interaction between restructurings plays an important role. While a restructuring may strengthen or weaken the incentive of a second restructuring, the interaction invariably leads to more mergers and fewer divestitures. This may account for the observation that in real life, mergers are very common while divestitures are less so.

Keywords: divestitures, mergers, endogenous mergers, demand shocks, industry reorganization

JEL Codes: D43, L11, L13, L41

1 Introduction

Ever since Salant et al.'s (1983) seminal paper, economists have realized that a merger may be unprofitable due to adverse reactions from non-merging firms. A merger benefits its participants by reducing competition between them. The reduced competition, however, is a public good that is available to all firms in the industry. Because of this externality, the merging firms cannot reap all of the benefits from the merger. Moreover, in the process of free riding on the reduced competition, non-merging firms become more aggressive (i.e., expanding their outputs in Cournot competition), further reducing

*Qiu: School of Economics and Finance, the University of Hong Kong. Zhou (corresponding author, wzhou@business.hku.hk): School of Business, the University of Hong Kong. We thank Tingyi Shi for excellent research assistance, and Ivan Png and seminar participants at Fudan University for helpful comments.

a merger's profitability. It is this response from non-merging firms that may render a merger unprofitable.

When a merger is unprofitable, the reverse of it, namely a divestiture, may become profitable. A divestiture breaks up a firm into autonomous entities that compete independently in the product market. As compared to a merging firm, a divesting firm faces the opposite tradeoff: The newly introduced competition between the autonomous units hurts their joint profits, but it has the benefit of forcing rival firms to retreat in competition. This practice of creating competing units to fight a firm's existing rivals is common in real life. Dealers and franchisees are usually instructed to compete aggressively without regard for the brand's other businesses.¹ Joint ventures often compete directly with the participating firms. Competing real estate agencies send (too) many agents to developers' showrooms. Producers of consumer packaged goods routinely launch several new products which compete against each other. Airlines increase flight frequencies despite cannibalization. Universities offer many MBA and EMBA programs which compete for the same students.² That also seems to be the logic behind the M-form structure (Chandler, 1962; Williamson, 1975) observed in the U.S. automobile and liquor industries (Schwartz and Thompson, 1986; Baye, et al., 1996).

While merger news appears in the media almost daily, this kind of divestitures is relatively rare.³ Similarly, there have been many studies of mergers, both theoretical and

¹Ford Motor Company "pursued a consistent policy of increasing distribution outlets, thus increasing price competition among its distributors and enraging them" (Tedlow, 2003, p.167). In retailing, closer location of shops can be a way to fend off competition. The two major supermarket chains in Hong Kong, ParknShop and Wellcome, have roughly the same number of shops and comparable revenues, but they follow different location strategies. Wellcome stores are closer to one another than their counterparts in the other chain. Since ParknShop belongs to a conglomerate led by tycoon Li Ka-shing who has a substantial power in Hong Kong's real estate market, one possible explanation is that ParknShop forecloses competition through its control of estate properties. Without such a power, Wellcome has to resort to a (more costly) strategy of locating its stores more densely.

²Of the two prominent universities in Shanghai, Fudan University offers nine MBA and EMBA programs, while Shanghai Jiaotong University offers seven such programs. Both universities also have numerous Executive Development Programs.

³Divestiture is generally defined as the sale of subsidiaries, divisions or a minority share of a firm's equity to a new owner. According to *Mergerstat Review*, 30% of all announced merger and acquisitions in 2007 involved divestitures, a total of 3,171 cases. Many firms, especially conglomerates, both merge and divest. In 2005 alone, GE had 17 divestitures and 28 acquisitions. JP Morgan had 10 divestitures and 17 acquisitions. In this paper, divestiture means specifically that a new competitor is created. It requires that (1) the divested entity produces the same product as the residual parent so that they

empirical, but many fewer of divestitures. No attempt has been made to put mergers and divestitures into a coherent economic model, even though it is obvious that both may happen in the same industry.

In the real world, the automobile industry seems to be in perpetual mergers and divestitures, including the high-profile marriage between Daimler-Benz and Chrysler in 1998 and their divorce nine years later. In the tobacco industry, RJR Nabisco sold its international tobacco business to Japan Tobacco in 1999, and later spun off its domestic tobacco business as R.J. Reynolds Tobacco Company, which in 2004 merged with Brown & Williamson Tobacco Corporation. Similar dynamics can be observed in other industries such as banking.⁴ In the popular media, analysts sometimes explain a merger or divestiture as a preemptive or defensive response to another firm's restructuring attempts, highlighting the importance of interactions among restructurings.⁵

This study was designed to fill a gap between reality and economic theory by explaining the implications of a theory which allows firms to engage in both mergers and divesti-

compete directly; and (2) the number of independent firms in the industry increases, which precludes partial divestitures in which part of a firm is sold to an existing competitor. Many divestitures in real life do create new competitors, at least in the future if not at the time of the divestiture. Although a divested unit may not be producing a competing product, it may very well develop one in the future once it becomes independent. Although the new owner may be an existing firm, it may not operate in the industry prior to the acquisition, so the divesting firm indeed creates its own competitor. For example, Siemens planned in early 2009 to divest its 34% stake in Areva NP, a Franco-German joint venture in nuclear reactors, and develop its own nuclear capabilities (*The Economist*, 1/29/09). Siemens did not operate any nuclear business of its own until after the divestiture. As another example, Chinese carmaker Geely bought Volvo from Ford in early 2010. Geely's president remarked that Volvo would now have the freedom to "enter market segments that were previously closed to it because they were occupied by models from Jaguar, Land Rover or Ford itself" (*The Economist*, 3/31/10). Thus, Ford's divestiture created its own competitor. Fast-food chain Wendy's spun off fast-growing Tim Hortons in 2006 after realizing that "Tim's was beginning to compete directly with Wendy's" (*The Economist*, 9/23/06). Note that the spinoff will increase competition between the two businesses rather than reduce it.

⁴ABN AMRO, a Dutch bank, has been pressed by its largest shareholder, TCI, a hedge fund, to break itself up. Barclays Bank of Britain came to the rescue with a plan to merge with ABN. The deal included a sale of ABN's US division, LaSalle, to Bank of America. Two days later, ABN received a hostile bid from a European consortium consisting of Royal Bank of Scotland, Santander of Spain and the Dutch-Belgian group Fortis, which aimed to dismantle ABN. This bid was conditional on LaSalle not being sold to Bank of America (*The Economist*, 4/26/2007).

⁵SAP bought smaller firms "to stop them going to Oracle" (*The Economist*, 10/20/07). Gillette merged with Procter & Gamble to avoid being taken over by Colgate-Palmolive (*The Economist*, 8/11/07). Google kept preempting Yahoo! by buying part or all of AOL, YouTube, Facebook, MySpace, and DoubleClick (*The Economist*, 5/12/07). Porsche bought 30% of Volkswagen for fear that Volkswagen might be broken up or be merged with another company (*The Economist*, 3/31/07). The U.K. bank NatWest broke itself up in response to a hostile takeover bid from the Bank of Scotland (BBC, 10/27/99, cited by Lambrecht and Myers, 2007).

tures. We were particularly interested in three broad questions. First, what determines the profitability of a merger or divestiture? Second, how does one firm's restructuring affect another firm's restructuring decisions? And third, how does an industry reorganize through mergers and divestitures?

The results show that restructuring is profitable only in a market of moderate size. If the market is very large, a divestiture generates a negative surplus; a merger surplus, although positive, is too small to cover the merger's costs. A mirror result holds if the market is very small: a merger surplus is negative, and a divestiture surplus, although positive, is too small to cover the divestiture's costs. Because restructuring is profitable only if the market is of moderate size, reorganization of an industry can be attributed to exogenous demand shocks that change the market's size.

Profitability, however, is neither necessary nor sufficient for a restructuring to take place. A potentially profitable divestiture may be preempted and an unprofitable merger may nevertheless be carried out. Our analysis shows that a merger always raises the incentive for a subsequent merger, but its impact on divestiture incentives depends on the divestiture cost and market size. A divestiture has the opposite effects. These interactions are demonstrated in an interesting case in which two firms merge in order to enhance a third firm's incentive to divest, which results in a merger rather than the divestiture. Therefore, a merger can, paradoxically, be induced by strengthening one of the participants' incentive to divest. As a result, when divestitures become easier (due to, say, lower divestiture costs), we may see more mergers rather than more divestitures.

Because a merger benefits rival firms while a divestiture hurts them, firms usually attempt to precipitate other firms' mergers and to prevent them from divesting. There is a strong tendency for an industry to become more concentrated through a series of mergers even when market conditions favor divestitures and are unfavorable for mergers. This may explain why, in real life, mergers are more common than divestitures.

Our study highlights the importance of combining mergers and divestitures in a single model in understanding industry dynamics. When only mergers are considered,

scholars have found that the incentive to merge may be enhanced by other mergers (Qiu and Zhou, 2007). The results of this study show that the incentive to merge can also be enhanced by the possibility of divestiture. When only divestitures are considered, it has been shown that the incentive to divest is so strong that an industry tends to become completely decentralized (Corchon, 1991; Polasky, 1992; Baye et al., 1996). Our results demonstrate that the direction of an industry's evolution can be reversed by the possibility of merging.

There has been much economic research on mergers but much less on divestitures (also called strategic divisionalization in the literature). No previous study has combined the two activities in a single model. Ray and Vohra (1999) and Macho-Stadler et al. (2006) have studied endogenous mergers through sequential coalition formation. Rather than focusing on equilibrium coalition structure as both studies do, we are mainly interested in the interaction between restructurings. This is done by introducing an exogenous variable that affects the profitability of restructuring and by showing how the profitability condition is altered by a previous restructuring. Much closer to the present research is a study by Qiu and Zhou (2007) of the interaction between endogenous mergers. They found that mergers are strategic complements and therefore tend to occur in waves.⁶ That study, however, used constant marginal costs and did not consider divestitures.

In divestiture studies, Corchon (1991), Polasky (1992) and Baye et al. (1996) have all shown that firms can gain competitive advantage through strategic divisionalization by committing to larger joint outputs. Schwartz and Thompson (1986) related divestitures to changes in demand. Lewis (1983) and Schwartz and Thompson (1986) demonstrated the advantage of divisionalization to deter entry.⁷ These studies all assumed constant

⁶In that study as well as the present one, the impact of one merger on another is endogenously derived from a standard Cournot model. In some other studies, by contrast, the impact is exogenously given, so under some conditions mergers may become strategic substitutes, giving rise to preemptive mergers. See Nilssen and Sorgard (1997) for a non-cooperative game and Horn and Persson (2001) for a cooperative game. Fridolfsson and Stenrek (2005) also demonstrated preemptive incentive of mergers, where a second merger is not even feasible due to the assumption that there are only three firms and monopolization is prohibited.

⁷Entry can also be deterred through product proliferation (Schmalensee, 1978; Bonanno, 1987), the practice of offering many variations of the same products, which is similar to divestiture.

marginal costs and invariably found (excessively) strong incentives to divest.⁸ None of them considered mergers.

Mialon (2008) has demonstrated why a merged entity may choose to keep the merging firms as independent competitors rather than fully integrating them. The tradeoff between M-form and full integration in her model corresponds to the profitability of a single, exogenous divestiture in our model. She did not consider multiple endogenous restructurings and the interactions among them, which is the focus of the present paper.

Our analysis has shown that exogenous demand shocks lead to industry reorganization through a series of mergers and divestitures. Direct and indirect evidence can be found in the reports of previous empirical studies. Mulherin and Boone (2000) studied the acquisition and divestiture activities of 1305 firms from 59 industries in the 1990s and found that half of the firms were acquired or had made a major divestiture. Acquisitions and divestitures were clustered by industry. Other empirical studies have shown that mergers occur in waves and were driven by industry-wide shocks, and that mergers strongly cluster by industry within a wave (Andrade et al., 2001; Andrade and Stafford, 2004; Harford, 2005; Jensen, 1993; Mitchell and Mulherin, 1996; Morck et al., 1988). The popular media also often attributes restructuring to a positive or negative demand shock.⁹

2 The Model

Consider an industry with n identical firms producing a homogenous product. The production cost of firm i , given its capital t_i and production quantity q_i , is assumed to

⁸Yuan (1999) has shown that the incentive to divest is weakened if products are differentiated. Tan and Yuan (2003) provided an alternative theory of divestitures: Competing conglomerates may divest complementary product lines in order to mitigate competition in the product market.

⁹Merger activity “usually takes place in good times.” (*Wall Street Journal*, 2/26/97, citing business historian Robert Sobel and his study of mergers in the 1890s, the 1920s, the 1960s and the 1980s.) Decreased demand (and increased input prices and more fierce competition) was said to be the driving force in the merger between Daimler and Chrysler (*The Economist*, 2/17/07), the consolidation of the flower market in The Netherlands (*The Economist*, 5/12/07), and the merger wave in the pharmaceutical industry in 2006 (*The Economist*, 9/30/06).

be

$$C(t_i, q_i) \equiv \frac{q_i^2}{2t_i}.$$

This cost function can be viewed as a short-run cost derived from a Cobb-Douglas production function,¹⁰ and has been assumed by Perry and Porter (1985) and McAfee and Williams (1992) in their studies of mergers.¹¹ In a merger or divestiture, the merging firms and divested divisions will be called insiders, and all other firms will be called outsiders.

Allow the firms to play a two-stage game. In the first stage, the firms are ordered randomly. They then take turns according to the order to choose from three options: to remain independent, to divest itself, or to propose a merger with the next firm.¹² The meaning of each option will be explained in a moment. We assume that a merged or divested firm is not allowed to take any further action. The first stage ends when all firms in the industry have made their choices. In the second stage, all remaining firms play a Cournot game and receive their Cournot payoffs. Demand in the product market is given by $p = a - bQ$ with $Q = \sum_{i \in N} q_i$ and $a, b > 0$.

Independence is to commit to not participating in any merger or divestiture in the whole game.¹³ Divesting involves dividing a firm into two independent, smaller, and equal-sized units,¹⁴ which are termed divisions in accordance to the strategic divisionalization literature. It must be emphasized however that a division here is not in the usual sense of being a part of a larger corporation.¹⁵ Rather, it is an offspring which will

¹⁰All firms possess the same constant-returns-to-scale technology $q = (tl)^{\frac{1}{2}}$, in which t is capital and l is labor. In the short run when its capital is fixed at t_i , firm i 's variable cost is $C_i \equiv \min_{l_i} w l_i$ subject to $q_i = (t_i l_i)^{\frac{1}{2}}$, in which w is the wage rate. The minimum cost is $\frac{w}{t_i} q_i^2$. If $w = \frac{1}{2}$, the assumed cost function obtains.

¹¹Similar cost structure has been used by Fumagalli and Vasconcelos (2009) in the case of international mergers, and Farrell and Shapiro (1990) for the investigation of asset ownership changes through investment, partial asset sales and joint ventures.

¹²Because firms are identical, the choice of the merger partner is inconsequential, and we assume that a merger is always proposed to the next firm.

¹³In real life, a firm can commit to a certain extent to "doing nothing" by announcing publically that will will not engage in any major restructuring in the near future.

¹⁴If the divesting firm can choose an arbitrary allocation of its capital between the two units, its payoff will be W-shaped in the allocation: It is maximized at either equal split or no-split.

¹⁵At the moment of divestiture the parent dissolves itself. There is no controlling company. In fact that is the whole point of conducting costly divestitures: Assets are broken up and put into the hands

compete in the product market independently with other firms including the parent's other offsprings. The divesting firm's payoff is the joint profits of the two divisions net of a divestiture cost f_d .¹⁶

When a firm proposes a merger (to the next firm in the line), the receiver of the proposal may accept or reject it. If the proposal is accepted, each merging firm will pay a merger cost f_m and receive half of the merged entity's profit.¹⁷ If a merger proposal is rejected, the proposer will choose between divestiture and independence.¹⁸

Due to the transaction costs (f_d for a divestiture and f_m for a merger), it is useful to distinguish restructuring surplus from restructuring profitability. The surplus of a restructuring is the participating firm's net gain from the restructuring gross of the transaction cost, while the profitability is the net gain net of the transaction cost. It is possible for a restructuring to be unprofitable due to the transaction cost even when the surplus is positive. The presence of transaction costs can partly justify the restrictive assumption that each firm can restructure only once. Because divestiture surplus decreases as the parent's capital becomes smaller, given the fixed divestiture cost, further divestiture may not be profitable even if it is allowed. We have also excluded the possibility of divesting into more than two divisions. This can be justified if the divestiture cost is convex in the number of divisions so that splitting into two is optimal. By the same token, if the merger cost is sufficiently convex in the merging firms' capital, a firm will not engage in two or more rounds of mergers even if it is permitted.

of different owners so that these units will indeed compete independently.

¹⁶We can imagine that each division is sold to a different owner. If there are many potential buyers, the parent can extract all the surplus through the sale prices of the divisions.

¹⁷An equal share is a natural assumption given that the firms are identical. If the bargaining power of the two merging firms is unequal if, for example, the proposer has all of the bargaining power, then the distribution of the merger surplus depends on the move order. But if the order is randomized, each firm will again expect to enjoy half of the merger surplus, so our assumption can be viewed as a reduced form.

¹⁸Only profitable merger (in the sense that the proposer is better off proposing) are proposed. However, not every proposal will be accepted. Since information is perfect, there is no uncertainty concerning the receiver's response, and there is no point proposing a merger that will be rejected. In equilibrium, therefore, only mergers that will be accepted are proposed. Basically, when a firm makes its choice, it compares its payoff from the three options in the respective continuation games, where the merger payoff is conditional on the proposal being accepted. Of course, the receiver's choice between acceptance and rejection will be analyzed and, as can be seen from later analysis, a receiver does sometimes reject a merger proposal.

Unlike most divestiture studies, we adopted a cost structure with increasing marginal costs. This cost structure has at least two advantages over constant marginal costs. First, it enables the modeling of divestitures as reverse mergers. If marginal costs are constant, to merge several firms is to eliminate all but the most efficient one, so a merged firm is exactly the same as one of the merging firms. Reversing this process to generate divestitures will therefore pose a conceptual difficulty: How can a division be created out of nothing? Under increasing marginal costs, the merger process is different. It can be interpreted as pooling some kind of assets from the merging firms and is therefore readily reversible to generate divestitures.¹⁹ Second, under increasing marginal costs, the strength of restructuring incentive is just right—mergers and divestitures can be profitable, but only under certain conditions. When marginal costs are constant, by contrast, the incentive to merge is too weak, while the incentive to divest is too strong.²⁰

3 Profitability of and Interactions between Restructurings

3.1 Cournot outcome

Although the firms are assumed identical to begin with, restructuring may result in heterogenous firms competing in the second-stage Cournot game. Consider an arbitrary set, Z , of firms with capital $\{t_k\}_{k \in Z}$. Firm i 's profit is $\pi_i = pq_i - C(t_i, q_i) = (a - bQ_{-i} - bq_i)q_i - \frac{q_i^2}{2t_i}$, in which $Q_{-i} = \sum_{k \in Z \setminus i} q_k$. The first-order condition is $a - bQ_{-i} - 2bq_i - \frac{q_i}{t_i} = 0$, which leads to the following Cournot equilibrium (see the Appendix). Let $g_i = \frac{bt_i}{1+bt_i}$ and $G = \sum_{k \in Z} g_k$. Then,

$$\pi_i^Z = \frac{a^2 g_i (1 + g_i)}{2b(1 + G)^2},$$

with $q_i = \frac{a}{b} \frac{g_i}{1+G}$ and $Q = \frac{a}{b} \frac{G}{1+G}$. Consequently i 's market share is $s_i \equiv \frac{q_i}{Q} = \frac{g_i}{G}$. The variable $g_i \in (0, 1)$, referred to as the *power* of firm i , is increasing and concave in t_i .

¹⁹ Although a merging or divesting firm does not have any cost advantage or disadvantage, a merged entity is larger while a divested offspring is smaller than the divesting firm, a feature that conforms to the common understanding of what a restructuring is about.

²⁰ If firms are identical, a two-firm merger is never profitable when the industry has at least three firms (Salant, et al., 1983), and every firm will divest into an infinite number of divisions even when the industry has only two firms, leading to perfect competition (Corchon, 1991).

Accordingly, G is the aggregate power of all competing firms in the industry.

The demand intercept, a , enters the Cournot profits only through the common coefficient a^2 and so affects firms' incentives to merge or divest only through its comparison with the transaction costs f_d and f_m . Without loss of generality, normalize $a \equiv \sqrt{2}$. Then,

$$\pi_i^Z = \frac{g_i(1 + g_i)}{b(1 + G)^2}.$$

The slope of the demand, b , plays a pivotal role in this model. A larger b indicates a smaller market size.²¹ Note that a firm's Cournot profit is a decreasing, convex function of b . When b approaches zero (the market is very large), π_i approaches t_i and firm i 's market share approaches $\frac{t_i}{\sum_{j \in Z} t_j}$. On the other hand, when b approaches infinity (the market is very small), π_i approaches zero and s_i approaches $\frac{1}{z}$, where $z \equiv |Z|$ is the number of firms in Z . In other words, when the market is large, a firm's capital level is important—each firm's market share is proportional to its capital. When the market is small, capital no longer makes any difference—all firms have equal market shares.

Market size affects not only the relevance of capital but also the interaction among firms. In Cournot competition, firms respond to a reduction in a competitor's output by expanding their own, and the expansion depends on market size if marginal costs are increasing. When the market is large (b is small), every firm operates at high marginal costs; the expansion will be limited. In that case, interaction among firms is weak; firms act as if they are monopolists. Conversely, when the market is small, firms operate at

²¹Whether to normalize the demand intercept, a , or the slope, b , is not an arbitrary choice. It is dictated by the cost structure. For linear demand, when marginal costs are constant, merger profitability is mainly affected by a (Qiu and Zhou, 2007). When marginal costs are increasing, as is the case here, a becomes a scaling factor, and merger profitability is mainly affected by b once a is normalized. In understanding the analysis, it is always useful to bear in mind this cost structure. For example, as a market grows larger, competition is reduced as expansion becomes increasingly costly. This would not have been the case had marginal costs been constant.

Market size is generally represented by demand intercept. We do not dispute that. Our point is simply that, given the model's assumption about cost structure, b is the major parameter that affects restructuring profitability and hence the focus of our discussion. To the extent that, for given a , doubling the market size corresponds to halving b , we can interpret b as representing market size. Such interpretation is not perfect, though, as b represents not only market size but also demand elasticity. It is desirable to have a more accurate interpretation of the demand slope, but "market size" is the best we have come up with so far.

low marginal costs and the interaction is strong. This inverse relationship, that smaller markets strengthen firms' interaction, can be seen more clearly from the best response functions. Firm i 's best response is $q_i = \frac{a-bQ_{-i}}{2b+\frac{1}{t_i}}$, so $\left| \frac{dq_i}{dq_j} \right| = \frac{1}{2+\frac{1}{bt_i}}$, which increases with b .

It will become apparent that the profitability of a restructuring depends crucially on outsiders' responses. The above discussion relates outsiders' responses, be they expansion or contraction, to market size: When the market is small, the response from outsiders is strong; when the market is large, the response is weak.

3.2 Merger surplus and market size

When two firms (say, i and j) merge, they will allocate their total production between them in an optimal way. The merged entity's production cost of producing q units of output will be $\frac{q^2}{2(t_i+t_j)}$, which allows the interpretation that i and j pool their capital in the merger. This interpretation is particularly useful because divestitures, as the reverse of mergers, can then be considered as the decomposition of the divesting firm's capital.

When i and j merge, the merged entity's power becomes

$$\begin{aligned} g_{ij} &= \frac{b(t_i + t_j)}{1 + b(t_i + t_j)} \\ &= \frac{g_i + g_j - 2g_i g_j}{1 - g_i g_j} < g_i + g_j. \end{aligned}$$

Therefore, a merger reduces the merging firms' combined power and consequently the industry's aggregate power. Because outsiders' power levels do not change, each outsider's output, market share and profit all increase and, as a result, the combined output and market share of the insiders both decrease.²²

Consider an exogenous merger in Z (i.e., no other change to the industry's organization) between two identical firms, i and i' . If each merging firm's capital is t_i , each firm's profit before the merger will be $\pi_i^Z = \frac{g_i(1+g_i)}{b(1+2g_i+H)^2}$, where $H = \sum_{k \in Z \setminus \{i, i'\}} g_k$. After

²²Total industrial output $Q = \frac{a}{b} \frac{G}{1+G}$ decreases when G decreases. Because every outsider's output increases, the combined output of the two insiders must decrease. The total market share remains at 1. Because every outsider's market share increases, the combined market share of the two insiders must decrease.

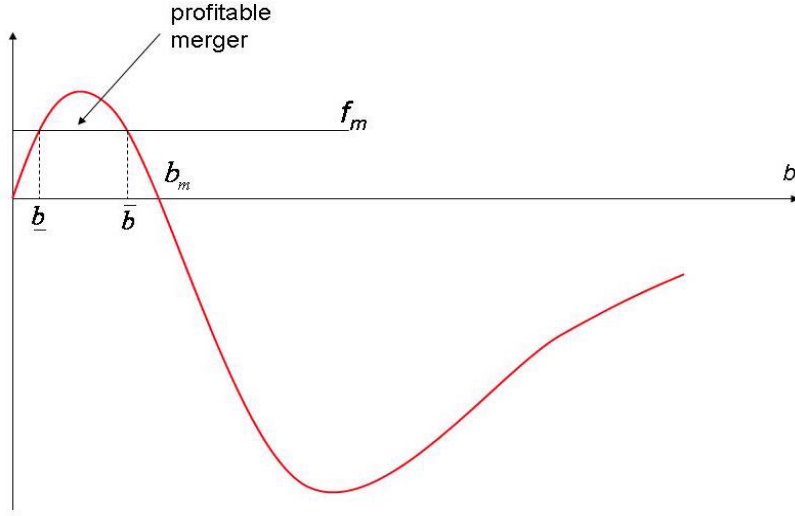


Figure 1: Merger surplus when $z = 4$.

the merger, the merged firm's profit is $\pi_{ii'}^{Z'} = \frac{g'(1+g')}{b(1+g'+H)^2}$, where ii' represents the merged entity, $Z' = Z \setminus \{i, i'\} \cup \{ii'\}$, and $g' = \frac{2bt_i}{1+2bt_i}$. Thus, a merger generates a surplus (gross of the merger cost) to each merging firm as

$$\begin{aligned} M_{i,i'}^{Z'} &\equiv \frac{1}{2}\pi_{ii'}^{Z'} - \pi_i^Z \\ &= \frac{b^2 t_i^3 [(1 - 2H - 3H^2) + 4(1 - 2H - H^2)bt_i]}{[1 + H + (3 + H)bt_i]^2 [1 + H + (4 + 2H)bt_i]^2}. \end{aligned}$$

When $z > 2$, $M_{i,i'}^{Z'} > 0$ if and only if b is smaller than some critical value (i.e., the market is sufficiently large).²³ The proof of the property is presented in the Appendix. Figure 1 shows $M_{i,i'}^{Z'}$ as a function of b , where Z consists of four firms, each with unit capital. The merger surplus is N-shaped with the left part above zero and the right part below zero. A merger presents the insiders with the following tradeoff. If outsiders do not change their outputs, the surplus must be positive, as the two insiders internalize the competition between them by reducing their outputs.²⁴ However, because the insiders reduce their outputs, outsiders will expand, reducing the merger's surplus. The net effect

²³If $z = 2$, $M_{i,i'}^{Z'} \geq 0$ for any b .

²⁴If the two merging firms have different capital, the merger has an extra benefit in the form of cost savings: for any given total output of the two firms, the merged entity's production cost is smaller than the sum of the two merging firms' costs.

depends on how much outsiders expand. As explained earlier, when b is small, outsiders expand little, and so the surplus tends to be positive. Note that as $b \rightarrow 0$ the merger surplus will approach zero. The benefit of a merger comes from the reduced competition between insiders. When the market is very large (b is very small), there is not much competition to begin with, so the merger surplus will be small.

The above findings can be summarized as follows:

Lemma 1: *For any given merger, there exists a $b_m > 0$ such that the merger surplus is positive if and only if $b \in (0, b_m)$. Furthermore, the merger surplus approaches zero as $b \rightarrow 0$.*

The lemma says that when marginal costs are increasing, a positive merger surplus is associated with high demand. Qiu and Zhou (2007) have shown that if firms have constant but different marginal costs, the merger surplus is positive if and only if the demand intercept is smaller than a critical level, i.e., a positive merger surplus is associated with low demand. These two conclusions complement each other, as they correspond to different cost structures. When capacity is not a concern (flat marginal costs), low demand is conducive to mergers because outsiders' expansion will be limited. By contrast, when capacity is a concern (increasing marginal costs), high demand is conducive because, again, the expansion of outsiders is limited. In both cases, limiting the expansion of outsiders is the key, and different cost structures translate into different demand conditions.

When b is relatively small so that the merger surplus is positive, increasing b has three effects on the surplus. A higher b strengthens the interaction among firms, which implies that (1) the benefit of reducing competition between the insiders is larger; and (2) outsiders are more responsive to the merger. In addition, a higher b means that (3) the insiders' profits before and after the merger are both smaller. The first effect increases the merger surplus, while the second and third effects decrease the surplus.²⁵

²⁵When $z = 2$, the second effect is absent, but the tradeoff between the first and third effects still exists, leading to the same inverse U relationship for the positive part of the merger surplus.

When b is small, the first effect dominates so the surplus increases with b . The opposite is true when b is large.

3.3 Divestiture surplus and market size

Given our definition that divestiture is to break up a firm into two autonomous divisions, divesting (into two divisions) is the reverse of merging (these divisions back into one firm). As opposed to a merger's pooling of the merging firms' capital, divestiture decomposes the parent firm's capital. As a result, a divestiture increases the divisions' combined power and consequently the industry's aggregate power. Each outsider's output, market share and profit decrease and, consequently, the combined output and market share of the insiders (i.e., the two insiders) both increase.

The surplus of divesting firm i in Z is

$$\begin{aligned} D_i^Z &\equiv 2\pi_{i/2}^{Z_i} - \pi_i^Z \\ &= \frac{b^2 t_i^3 [(3G_i^2 + 2G_i - 1) + 2(G_i^2 + 2G_i - 1)bt_i]}{[2 + 2G_i + (3 + G_i)bt_i]^2 [1 + G_i + (2 + G_i)bt_i]^2}, \end{aligned}$$

where $Z_i = Z \setminus \{i\} \cup \{\frac{i}{2}, \frac{i}{2}\}$ with $\frac{i}{2}$ being one of i 's two divisions, and $G_i = \sum_{k \in Z \setminus i} g_k$. This surplus is equal to the negative of the surplus of merging the two $\frac{i}{2}$ firms in Z_i . If $z > 1$, $D_i^Z \geq 0$ if and only if b is greater than some critical value.²⁶ In fact, just as a merger surplus is N-shaped in b , a divestiture surplus is inverse N-shaped in b with the left side below zero and right side above zero (that is, Figure 1 is turned upside down).

The following lemma summarizes the properties of divestitures, which parallel those of mergers:

Lemma 2: *For any given divestiture, there exists a $b_d > 0$ such that the divestiture surplus is positive if and only if $b > b_d$. Furthermore, the divestiture surplus approaches zero as $b \rightarrow \infty$.*

When a firm divests, it creates competition among the resulting divisions, which seems to be only damaging to the divisions' joint profit. However, precisely because the

²⁶If $z = 1$ (and hence $G_i = 0$), $D_i^Z < 0$.

divisions compete independently, their joint production will expand, forcing outsiders to contract, which will benefit the insiders.²⁷ Therefore, the benefit of divestitures comes from the commitment power of the divisions to jointly produce more, which forces outsiders to produce less. The sign and magnitude of a divestiture surplus depend on how much outsiders shrink. When the market is large, the interaction between firms is weak. Outsiders will not shrink much in response to the divestiture, and the surplus is negative. When the market is small, it is easy to force outsiders to shrink, and the surplus becomes positive. However, when the market is very small, the parent and the insiders' profits are both very small. The divestiture surplus, although positive, will be small.

3.4 Profitability of restructuring

An exogenous restructuring, be it a merger or a divestiture, faces the tradeoff between an internal effect and an external effect. In the case of a merger, the internal effect is that the two merging firms reduce the competition between them to their benefit. The external effect is that outsiders take the opportunity to expand, which damages the merging firms. In the case of divestitures, the effects are opposite: The internal effect is the creation of competition between the divisions, which damages the divesting firm, and the external effect is that outsiders are forced to shrink, which benefits the divesting firm.

When marginal costs are increasing, outsiders' responsiveness and consequently the sign of a restructuring surplus depends on the market size. In particular, if the market is large, every firm operates at high marginal costs and will therefore respond little to other firms' quantity changes. As a result, a merger surplus will be positive while a divestiture surplus will be negative. The opposite is true when the market is small.

Since every restructuring incurs a transaction cost, the profitability of a restructuring depends not only on the sign of the surplus, but also its magnitude, which again depends on the market's size. If the market is large, the merger surplus will be positive, but when

²⁷That is why when there are no outsiders ($z = 1$), the divestiture surplus is always negative.

the market is very large, there is not much competition between firms to begin with, so the benefit of reducing competition between merging firms will be small. The merger surplus, although positive, will be small, and the merger tends to be unprofitable due to the merger cost. Similarly, when the market is small, the divestiture surplus will be positive. However, if the market is too small, a firm's profit will be small whether or not it divests. The divestiture surplus, though positive, may not be large enough to cover the divestiture cost, and the divestiture tend to be unprofitable.

To summarize, when marginal costs are increasing and restructuring costly,

Proposition 1: *For any given restructuring (merger or divestiture), there exists a $\underline{b} > 0$ and a $\bar{b} \geq \underline{b}$ such that the restructuring is profitable if and only if $b \in (\underline{b}, \bar{b})$.*

Note that the range is an open set, which may be empty if the transaction cost is high. The proposition relates restructuring profitability to market size. Such a relation is illuminating because to understand why a restructuring takes place at a particular time we need to explain not only that it is profitable, but also why it did not take place earlier if it has been profitable all along. In other words, we need to identify a condition that can change the profitability of restructuring. According to Proposition 1, market size is such a trigger. A restructuring becomes profitable when b moves from outside (\underline{b}, \bar{b}) to within it, i.e., when the industry undergoes an exogenous shock to demand. If the original b was smaller than \underline{b} , the shock is negative. If the original b was greater than \bar{b} , the shock is positive. So restructuring may be caused by either a positive or a negative demand shock.

3.5 Interaction between restructurings

Since an industry may have multiple restructurings (for example, a wave of mergers involving multiple firms), a firm's choice about participating depends not only on the profitability of each restructuring considered in isolation, but also on other firms' restructuring activities. It is therefore important to understand how one restructuring alters the incentives related to a second restructuring. Note that a restructuring affects a second

one only by changing the aggregate power of outsiders in the latter restructuring. As a result, we only need to investigate the impact of a merger on a second restructuring (which may be a divestiture or another merger). The impact of a divestiture on a second restructuring will be exactly the opposite.

First let the second restructuring be a divestiture. A divestiture by firm i generates a surplus of

$$\begin{aligned} D &= 2\pi_{i/2} - \pi_i \\ &= \frac{2g_{i/2}(1 + g_{i/2})}{b(1 + 2g_{i/2} + G_i)^2} - \frac{g_i(1 + g_i)}{b(1 + g_i + G_i)^2}, \end{aligned}$$

where $g_i = \frac{bt_i}{1+bt_i}$, $g_{i/2} = \frac{b\frac{t_i}{2}}{1+b\frac{t_i}{2}}$, and $G_i = \sum_{k \in Z \setminus i} g_k$. The only impact of the preceding merger on this surplus is that G_i becomes smaller, and we find

$$\begin{aligned} \frac{dD}{dG_i} &= -\frac{4g_{i/2}(1 + g_{i/2})}{b(1 + 2g_{i/2} + G_i)^3} + \frac{2g_i(1 + g_i)}{b(1 + g_i + G_i)^3} \\ &= 2 \left[\frac{\pi_i}{1 + g_i + G_i} - \frac{2\pi_{i/2}}{1 + 2g_{i/2} + G_i} \right]. \end{aligned}$$

How G_i affects D depends on the comparison between π_i and $2\pi_{i/2}$ (i.e., the sign of D), as well as the comparison between $\frac{1}{1+g_i+G_i}$ and $\frac{1}{1+2g_{i/2}+G_i}$. The latter comparison is unambiguous because $g_i < 2g_{i/2}$. As a result, $\frac{dD}{dG_i} > 0$ at $D = 0$, meaning that the merger decreases the divestiture surplus where the surplus was zero, making it negative. When $D > 0$, $\pi_i < 2\pi_{i/2}$ so the sign of $\frac{dD}{dG_i}$ is ambiguous. It can be shown that, conditional on $D > 0$, $\frac{dD}{dG_i}$ is negative if and only if b is greater than a critical value. That is, a merger reduces the divestiture surplus when b is small, and raises the surplus when b is large.

Now let the second restructuring be a merger, which is the reverse of the divestiture discussed above.²⁸ The surplus on merging two $\frac{i}{2}$ divisions back into firm i is $M =$

²⁸Here we are discussing the impact of an exogenous merger on an exogenous restructuring, which may be a divestiture (of breaking up firm i into two $\frac{i}{2}$ divisions) or a merger (of combining two $\frac{i}{2}$ divisions back into one firm). That is why $M = -D$. It is not an equilibrium analysis, which deals with firm i 's endogenous choice of divesting (into two $\frac{i}{2}$ divisions) and merging (with the next firm, i' , which is not a merger between two $\frac{i}{2}$ divisions). Here we are interested in the qualitative impact of an exogenous merger on a second exogenous merger. Because a merger always raises the positive surplus of a second merger (Proposition 2), it does not matter whether the second merger is between two whole firms or two half-firms.

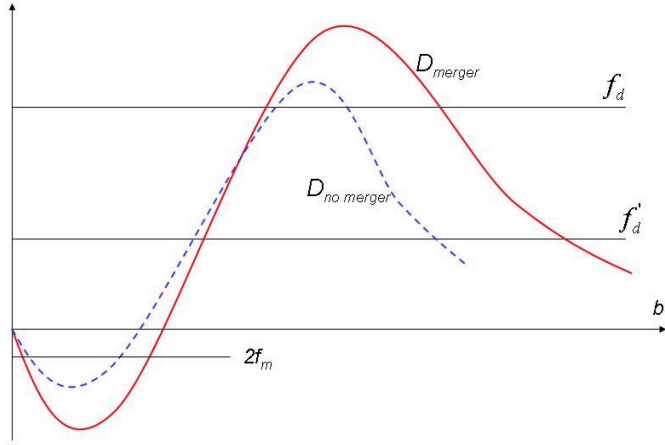


Figure 2: A merger's impact on a second restructuring

$-D = \pi_i - 2\pi_{i/2}$, so

$$\frac{dM}{dG_i} = 2 \left[\frac{2\pi_{i/2}}{1 + 2g_{i/2} + G_i} - \frac{\pi_i}{1 + g_i + G_i} \right].$$

Again, $2g_{i/2} > g_i$. When $M > 0$, $2\pi_{i/2} < \pi_i$ so $\frac{dM}{dG_i} < 0$, meaning that a merger always raises the positive surplus of a second merger.

Proposition 2: *A merger always raises the positive surplus of a second merger. It reduces the positive surplus of a divestiture at small b and raises the surplus at large b . A divestiture has the opposite effects.*

Figure 2 demonstrates how a merger affects a subsequent restructuring, where the dotted line is the surplus of the i divestiture without the preceding merger, and the solid line is the surplus with the merger. On both lines, the negative part represents the (positive) surplus of merging two $\frac{i}{2}$ divisions into firm i . The impact of a merger on a second restructuring is captured by the movement from the dotted line to the solid line (and the impact of a divestiture is captured by the opposite move—from the solid line to the dotted line). It is clear from the graph that after a merger, the (positive) surplus of a second merger increases, while the (positive) surplus of a divestiture shifts to the right: decreasing at small b and increasing at large b .

A merger's impacts on a subsequent restructuring can be understood as follows. A merger raises outsiders' profits. This is the direct effect, which tends to increase the surplus of any restructuring, be it a merger or a divestiture. Proportionally, however, a merger raises two outsiders' joint profits more if the two outsiders also merge. This is the feedback effect, which tends to raise a merger surplus and reduce a divestiture surplus. To understand the feedback effect, recall that when the two outsiders merge, all other firms take the opportunity to expand. But if the first merger has taken place, its participants will expand less in an effort to internalize the negative externality that one's expansion has on the other. This limited expansion will cause less damage to the second merger. In other words, by committing to a smaller expansion, the participants in the first merger create a more benign environment for a second merger. Conversely, a merger will create a harsher environment for a subsequent divestiture.

The direct and feedback effects reinforce each other when the subsequent restructuring is a merger, so the impact of the first merger is unambiguous. If the subsequent restructuring is a divestiture, however, the two effects work in opposite directions. When b is large, the interaction between firms is strong, and the first merger has a greater impact in raising outsiders' profits. The direct effect will dominate, and a merger raises the divestiture surplus if and only if b is large.

As can be seen from Figure 2, a merger enlarges the range of b for a profitable second merger regardless of the merger's cost. However, the impact on a divestiture depends on the divestiture's cost. If f_d is high, the profitable range for a divestiture is enlarged; if f_d is low, the range is shifted to the right. Therefore, a merger enhances the incentive for a second merger, but its impact on the incentive for a divestiture is more complicated, depending on divestiture costs and market size. When the divestiture cost is high, a merger enhances the incentive to divest; when the divestiture cost is low, a merger enhances the incentive to divest in a small market, but weakens the incentive in a large one.

It is of particular interest to focus on the case with high divestiture costs. Then,

a merger enhances both the incentive to merge and the incentive to divest.²⁹ This is mainly because a merger reduces competition in the industry, raising the profits of all other firms, who may then engage in restructurings of their own. The surplus from the restructuring, be it a merger or a divestiture, can therefore rise high enough to cover the transaction costs of the restructuring.

Because a merger enhances the incentives for a second merger, mergers are strategic complements.³⁰ On the other hand, because a divestiture weakens the incentives for a second divestiture (when divestiture costs are high), divestitures are strategic substitutes. As for the relation between mergers and divestitures, a merger strengthens the incentive to divest, but a divestiture weakens the incentive to merge, so mergers and divestitures are neither strategic complements nor strategic substitutes.

To summarize, mergers and divestitures are mirror processes. The two always have opposite impacts on the incentives for a subsequent restructuring. On the receiving side, however, the incentives for both types of restructuring can be enhanced by the same event such as a preceding merger.

4 Equilibrium Analysis for $n = 4$

So far we have focused on the profitability and interactions involved in exogenous restructuring. This will help us in this section analyze the equilibrium when firms' restructurings are endogenized. We will relate equilibrium choices to b . Since a firm's payoff changes discontinuously when other firms restructure (which depends on b), and since the number of subgames increases exponentially with the number of firms, a general analysis is intractable. We will resort to some specific examples which demonstrate some interesting

²⁹It may seem contradictory that the incentive to merge and the incentive to divest can both be enhanced by the same event, as divestitures are just reverse mergers. However, the reversibility simply means that the two surpluses must have opposite signs at the same b . It does not preclude the possibility that an event may increase the positive surplus of a merger (at some b), and at the same time increase the positive surplus of the reverse of the merger, namely a divestiture (at a different b). Note however that the reversibility does imply that a divestiture weakens both the incentive to merge and the incentive to divest.

³⁰This conclusion does not depend on the assumption of increasing marginal costs. It is also true when marginal costs are constant (Qiu and Zhou, 2007). Because mergers are strategic complements, they tend to occur in waves.

features of the equilibrium. To this end, assume $n = 4$ and $t_i = 1$ for every firm in the industry. We will analyze how the equilibrium depends on b for fixed values of f_m and f_d , and demonstrate how the equilibrium changes with f_d .

4.1 A relatively high level of transaction costs

Example 1: *Suppose $f_m = f_d = 0.0055$. Then for any b , there is a unique equilibrium: (i) when $b \in [1.13, 2.41]$, the first two firms merge, and the remaining two firms also merge; (ii) when $b \notin [1.13, 2.41]$, all four firms remain independent.*

The derivation of the equilibrium is presented in the Appendix. The equilibrium is shaped by two basic forces: the profitability of various mergers and divestitures, and the interaction between firms' restructuring activities. At the specified level of f_m and f_d , a merger is never profitable regardless of the outsiders' capital distribution, and a divestiture is profitable only when the three outsiders remain independent or two of them merge.

For $b \in [1.13, 2.41]$, once 1 and 2 have merged, firm 3's best choice is to merge with 4. If 3 divests or remains independent, 4 will always divest, which hurts 3. So 3's merger proposal is preemptive and strategic. It is strategic because the 3,4 merger is actually unprofitable in and of itself. In fact, the surplus of the merger is negative even without considering the merger's cost. Interestingly, 4 will accept the merger proposal even though its payoff will be reduced. This is because in the event of 4's rejecting the proposal, 3 will divest, which will hurt firm 4 even more.

So firms 3 and 4 agree to merge to avoid mutually damaging divestitures. The merger is so costly that firm 3 will make a different choice whenever 4's divestiture can be avoided by other means. If b is slightly below 1.13, firm 4 will divest only if 3 divests, so 3 will choose to remain independent. If b is slightly above 2.41, 4 will remain independent even if 3 divests. In either case, there is no need for firm 3 to propose any merger. The range $[1.13, 2.41]$ is therefore the only range of b in which firms 3 and 4, when not merging, will both divest, which is the worst outcome for both firms, and which can be avoided

only by a merger between them.

Even if b falls within $[1.13, 2.41]$, 3 and 4 will not merge unless 1 and 2 have merged. The 1,2 merger enhances firm 4's incentive to divest, which in turn forces 3 and 4 to merge. If 1 and 2 do not merge, firm 4's incentive to divest will be too weak (recall that a merger increases the incentive to divest),³¹ and as a result 3 will not pursue the 3,4 merger. The only way to induce the 3,4 merger is therefore for the 1,2 merger to occur first. In fact the 1,2 merger is unprofitable by itself (i.e., fixing whatever action that will be taken by 3 and 4), and is therefore also strategic.

In summary, both mergers are strategic. 1 and 2 merge to induce a subsequent merger, while 3 and 4 merge to avoid mutually damaging divestitures. What is particularly interesting is that *a merger can be induced by enhancing one of the participants' incentive to divest*. As discussed earlier, an outsider always benefits from a merger and is always hurt by a divestiture, so it seems that a firm should always try to strengthen other firms' merger incentives and weaken their divestiture incentives. Here a firm's incentive to merge is enhanced by enhancing its putative merger partner's incentive to divest. This illustrates interesting interactions between firms' restructuring choices.

Although both mergers are strategic in the sense of being unprofitable by themselves, when the mergers actually take place for $b \in [1.13, 2.41]$, each firm earns a higher payoff than when all of the firms remain independent.

4.2 Other levels of transaction costs

The previous equilibrium was derived for $f_m = f_d = 0.0055$. Let us now examine how the equilibrium changes by varying f_d while fixing the value of f_m at 0.0055. This analysis allows us to see how divestitures affect firms' merger decisions and thus the equilibrium outcome.

When divestiture is very costly (i.e., for $f_d \geq 0.0059$), all four firms remain indepen-

³¹In fact, if 1 and 2 do not merge, 4's incentive to divest can still be strengthened by a merger between firms 2 and 3. But the 2,3 merger is self-defeating because the only purpose of strengthening 4's incentive to divest is to force it to merge with 3, so 3 must be left alone to serve as the merger partner to firm 4.

dent regardless of the value of b . In relation to the previous equilibrium, this result shows that *mergers will be less likely when divestitures are infeasible* (due to, say, high divestiture costs). This is easy to understand. Although the equilibrium in Example 1 does not involve any divestiture, it relies on the force of divestitures to shape firms' choices. The first merger takes place in order to enhance firm 4's incentive to divest, which in turn forces firms 3 and 4 to merge. If divestitures are very costly, firm 4's incentive to divest will be too weak (even after the enhancement) to induce the 3,4 merger, which in turn renders the first merger meaningless. In the end, no firm will take any restructuring action.

When the divestiture cost is lower (i.e., for $f_d \in [0.0055, 0.0059)$), mergers start to appear at equilibrium. In fact, all equilibria have the same structure as that in Example 1: a wave of two mergers for moderate values of b , with the range of b for the merger wave enlarging continuously as f_d falls. As is clear from the previous analysis, the range of the equilibrium merger wave is in fact the range of b in which, conditional on firms 1 and 2 having merged, firm 4 will divest regardless of firm 3's choice. If the divestiture cost is lower, the range for firm 4's profitable divestiture will be wider, and so will be the range for the equilibrium merger wave. Therefore, *a lower cost of divestitures increases the frequency of mergers*.

Richer configurations with both mergers and divestitures emerge at equilibrium if f_d is further reduced. Two more examples are provided in the Appendix. In summary, it is possible for a restructuring equilibrium to involve no mergers. There may be one or more divestitures, and hence a divestiture wave. It is even possible for every firm in the industry to divest.

4.3 Discussion

In all of these cases, restructuring takes place only at moderate values of b . If the market is very large or very small, all four firms will remain independent. Therefore, any change to an industry's market structure, whether it involves mergers, divestitures

or any combination of the two, can be attributed to either a positive demand shock (i.e., the market is expanding) or a negative demand shock (i.e., the market is shrinking). The reason, of course, is that a given merger or divestiture is profitable only when the market size falls to moderate levels.

Profitability, however, is neither necessary nor sufficient for a restructuring to take place in equilibrium. Mergers can be carried out even though they are unprofitable, and divestitures are often avoided even though they are profitable. *There are fine details to the interaction between restructurings, but they always lead to more mergers and fewer divestitures.* The reason is easy to understand: Mergers benefit outsiders while divestitures hurt outsiders, so strategic actions (through restructuring) may be undertaken to induce mergers and/or preempt divestitures. This may explain why in real life, mergers are very common while divestitures (of this nature) are not.

The examples show how a merger can induce a second merger by enhancing one of the merging firms' incentive to divest. Although divestitures may not appear in equilibrium, the possibility plays a pivotal role in shaping merger choices. In particular, *the possibility of divestitures strengthens the incentive for mergers, so mergers may become more frequent when divestitures are more likely* (due to, say, lower divestiture costs).

5 Concluding Remarks

There may be many reasons why firms engage in restructuring. In this study we excluded any concern for cost benefits and focused instead on the competitive effects of restructuring, i.e. how restructuring alters the competition between insiders and the interaction between insiders and outsiders. We have reached three major conclusions. First, when marginal costs are increasing and restructuring is costly, a restructuring is profitable only in a market of moderate size, so an industry's reorganization can be attributed to demand shocks. Second, profitability is neither necessary nor sufficient for a restructuring to take place in equilibrium, as the interaction between firms' restructuring choices plays an important role. Third, interaction between restructurings invariably

leads to more mergers and fewer divestitures, creating a general tendency for industry concentration to increase.

Due to the complexity of the problem, we have restricted the model in a couple of ways, and the equilibria in Section 4 were derived under even more restrictions. Notice, however, that none of the above three conclusions depends on these restrictions. It will nevertheless be interesting to investigate how relaxing the assumptions will change the fine details of the equilibria. For example, we may allow a firm to engage in multiple restructurings or study how the equilibrium depends on the competitiveness of the industry (i.e., the number of initial competitors).

We have demonstrated that the profitability of restructuring depends crucially on the demand slope, b , which we interpreted as the market size. As mentioned in the text, this interpretation is imperfect because b may also represent demand elasticity. It will be interesting to investigate exactly which force is at work, the market size or demand elasticity. It is worth emphasizing again that the demand slope plays a pivotal role mainly because marginal costs are assumed to be increasing. Other researches have found that the role may also be played by the demand intercept when marginal costs are constant (Qiu and Zhou, 2007). Details putting aside, the message is that restructuring is triggered by a change in some exogenous variables. This approach of relating the profitability of restructuring to some underlying economic conditions is crucial for studying the interaction between restructurings. It differentiates the paper from the approach of endogenous coalition formation (for example, Ray and Vohra, 1999; Macho-Stadler et al., 2006), where such relations are absent.³²

To capture the strategic interaction between restructuring choices, we have assumed a two-stage sequential game. If the game is simultaneous or cooperative, the strategic effect will be lost. The order of firms' decision making was assumed to be random. Since the firms were assumed to be identical, the order is in fact inconsequential. If

³²Endogenous coalition formation has its merit, though, in the more natural game design, which will be crucial if a firm can participate in multiple restructuring or if firms are heterogeneous so that the order of moving and the choice of merger partners are also endogenized.

firms are heterogeneous, the order itself as well as the choice of merger partners can be endogenized (Qiu and Zhou, 2007).

In this model we have normalized the slope of the marginal cost curves and discussed the equilibrium in terms of the slope of the demand curve. It is clear that what really matters is the comparison between the two slopes, so the whole discussion can be carried out in terms of the coefficients of marginal costs, changes in which can be interpreted as production or technology shocks. There may be other factors which could trigger restructuring: entries and exits which change the number of firms, reduced transaction costs of mergers and divestitures, or a positive demand shock that increases the demand intercept.³³

By focusing on the redistribution of capital among firms within an industry through mergers and divestitures, we implicitly assume that the industry's total supply of capital is perfectly inelastic. This may be justified if the capital is industry-specific physical capital that cannot be increased quickly. Obviously a firm's capital may be augmented or depleted through other means such as investment, R&D, entry, exit, capital depreciation and so on. A richer model can be built to incorporate some of these elements. The setting also readily lends itself to the investigation of partial divestitures.³⁴

Such a model can be used to justify heterogeneous firm sizes even when there are no intrinsic differences among the firms. Starting from a hypothetical industry with identical firms, exogenous shocks may trigger mergers and divestitures that lead to heterogeneous firms. In other words, the distribution of firm sizes can be endogenized.³⁵ This will provide a foundation for firm heterogeneity, which has been the central theme of many recent studies in international economics.

Divestitures are voluntary in this formulation. In a different context, divestitures

³³Smaller f_m or f_d is an example of a parameter change that turns a restructuring from unprofitable to profitable. A larger a , the demand intercept, has the same effect.

³⁴In this model the firms were identical, so partial divestitures/mergers are never profitable. But if firms are heterogeneous, a partial divestiture may be optimal.

³⁵The distribution of firms in an industry can also be explained by endogenous entry costs (Sutton, 1992). In fact, such an approach for endogenizing firm sizes reminds one of the Maxwell-Boltzmann distribution of molecular speeds in a gas.

may be involuntary as a structural remedy for merger approvals (Leveque and Shelanski, 2003; Motta, 2004). For example, the proposed breakup of Microsoft into an operating system company and an applications firm was meant to create competition between the two offsprings. Investigating the effectiveness of such remedies with a cost structure like that used in the present study seems to be a fruitful direction for future research.

6 Appendix

Cournot Equilibrium

The first-order condition (FOC) leads to $bq_i = g_i(a - bQ)$, in which $g_i = \frac{bt_i}{1+bt_i}$. Summing the FOCs for all firms in Z yields $Q = \frac{a}{b} \frac{G}{1+G}$, in which $G = \sum_{j \in Z} g_j$. Plug Q into the FOC to obtain q_i .

Merger surplus positive if and only if b is smaller than some critical value

From the text, the merger surplus is

$$M_{i,i'}^Z = \frac{2b^2t_i^3[(1 - 2H - 3H^2) + 4(1 - 2H - H^2)bt_i]}{[1 + H + (3 + H)bt_i]^2[1 + H + (4 + 2H)bt_i]^2}.$$

Consider $z > 2$. $M_{i,i'}^Z = 0$ when $b = 0$. When $b \rightarrow 0$, $H \rightarrow 0$ and therefore $M_{i,i'}^Z > 0$. When $b \rightarrow \infty$, $H \rightarrow z - 2 \geq 1$ and therefore $M_{i,i'}^Z < 0$. Because $M_{i,i'}^Z$ is continuous in b , there is at least one $b_m > 0$ such that $M_{i,i'}^Z(b_m) = 0$.

To prove that b_m is unique, it suffices to show that $\frac{d(M_{i,i'}^Z)}{db} < 0$ for any $b_m > 0$ such that $M_{i,i'}^Z(b_m) = 0$, or equivalently to show that $\left. \frac{d\beta}{db} \right|_{b=b_m} < 0$, where

$$\beta(b) = (1 - 2H - 3H^2) + 4(1 - 2H - H^2)bt_i.$$

Let $H_0 = H(b_m)$. Because $1 - 2H - 3H^2 < 1 - 2H - H^2$, it must be true that $1 - 2H_0 - 3H_0^2 < 0$ while $1 - 2H_0 - H_0^2 > 0$, which means that $\frac{1}{3} < H_0 < \sqrt{2} - 1$. Let $t_j = \max_{k \in Z'} t_k$. Then $\frac{b_mt_j}{1+b_mt_j} \leq \sum_{k \in Z'} \frac{b_mt_k}{1+b_mt_k} = H_0 < \sqrt{2} - 1 < \frac{1}{2}$, so $b_mt_j < 1$. As a result, $H'(b_m) = \sum_{k \in Z'} \frac{t_k}{(1+b_mt_k)^2} \geq \sum_{k \in Z'} \frac{b_mt_k}{1+b_mt_k} \frac{1}{(1+b_mt_j)b_m} = \frac{H_0}{(1+b_mt_j)b_m} > \frac{H_0}{2b_m}$.

Because $\beta(b_m) = 0$, we have $t_i = -\frac{1}{4b_m} \frac{1-2H_0-3H_0^2}{1-2H_0-H_0^2}$. Then,

$$\begin{aligned} \left. \frac{d\beta}{db} \right|_{b=b_m} &= 4t_i(1-2H_0-H_0^2) - 2H'(b_m)[(1+3H_0) + 4b_mt_i(1+H_0)] \\ &\leq -\frac{1-2H_0-3H_0^2}{b_m} - 2\left(\frac{H_0}{2b_m}\right) \left[(1+3H_0) - \frac{1-2H_0-3H_0^2}{1-2H_0-H_0^2}(1+H_0) \right] \\ &= -\frac{1-4H_0+2H_0^2+6H_0^3+3H_0^4}{b_m(1-2H_0-H_0^2)} < 0 \end{aligned}$$

for $\frac{1}{3} < H_0 < \sqrt{2} - 1$.

Example 1

The following notations are used: $\pi_{t_i}^{\{t_j\}_{j \in Z}}$ is the Cournot profit of a firm with capital t_i in an industry where members' capital stocks are $\{t_j\}_{j \in Z}$. x_i is firm i 's payoff from action x in anticipation of what will happen, where $i = 1, 2, 3$, or 4 , and $x = m$ (merger), d (divestiture), or s (remain independent). ix means firm i takes action x ; $i + j$ means firms i and j merge; $ix \rightarrow jy$ means i 's action x leads to j 's action y .

(1) The subgame $1s$ (i.e., the subgame in which firm 1 has chosen s)

(i) If $2s$, then:

- If $3s$, then $4d$ for $b \in [1.14, 2.11]$ and $4s$ otherwise.
- If $3d$, then $4s$.
- If $3m$: if 4 accepts, 4's payoff is $\frac{1}{2}\pi_2^{\{1,1,2\}} - f_m$. If 4 rejects, then $3d4s$ for $b \in [1.14, 2.11]$ and $3s4s$ otherwise, in which case 4's payoff is $\pi_1^{\{1,1,\frac{1}{2},\frac{1}{2},1\}}$ for $b \in [1.14, 2.11]$ and $\pi_1^{\{1,1,1,1\}}$ otherwise. Firm 4's optimal choice is to reject the $3 + 4$ offer.
- As a result, the equilibrium in subgame $1s2s$ is $3d4s$ for $b \in [1.14, 2.11]$ and $3s4s$ otherwise. Firm 2's payoff in this subgame is

$$n_2 = \begin{cases} \pi_1^{\{1,1,\frac{1}{2},\frac{1}{2},1\}}, & \text{for } b \in [1.14, 2.11] \\ \pi_1^{\{1,1,1,1\}}, & \text{otherwise} \end{cases}$$

- (ii) If $2d$, then $3s \rightarrow 4s$ and $3d \rightarrow 4s$. Moreover, if $3m$ and 4 accepts, 4 will get $\frac{1}{2}\pi_2^{\{1, \frac{1}{2}, \frac{1}{2}, 2\}} - f_m$. If 4 rejects $3 + 4$, the result is $3s4s$, and 4's payoff will be $\pi_1^{\{1, \frac{1}{2}, \frac{1}{2}, 1, 1\}}$. 4's optimal choice is to reject. As a result, the equilibrium in subgame $1s2d$ is $3s4s$. Firm 2's payoff is

$$d_2 = 2\pi_{\frac{1}{2}}^{\{1, \frac{1}{2}, \frac{1}{2}, 1, 1\}} - f_d.$$

- (iii) If $2m$, then:

- If 3 accepts, then $4d$ for $b \in [1.13, 2.71]$ and $4s$ otherwise, in which case 3's payoff is

$$m_3 = \begin{cases} \frac{1}{2}\pi_2^{\{1, 2, \frac{1}{2}, \frac{1}{2}\}} - f_m, & \text{for } b \in [1.13, 2.71] \\ \frac{1}{2}\pi_2^{\{1, 2, 1\}} - f_m, & \text{otherwise} \end{cases}$$

- If 3 rejects, then $2d3s4s$ for $b \in [1.14, 2.11]$ and $2s3s4s$ otherwise. In this case, 3's payoff is

$$\begin{cases} \pi_1^{\{1, \frac{1}{2}, \frac{1}{2}, 1, 1\}}, & \text{for } b \in [1.14, 2.11] \\ \pi_1^{\{1, 1, 1, 1\}}, & \text{otherwise} \end{cases}$$

- 3's optimal choice is to reject.

- (iv) The equilibrium in subgame $1s$ is $2d3s4s$ for $b \in [1.14, 2.11]$ and $2s3s4s$ otherwise. Firm 1's payoff in the subgame $1s$ is therefore:

$$n_1 = \begin{cases} \pi_1^{\{1, \frac{1}{2}, \frac{1}{2}, 1, 1\}}, & \text{for } b \in [1.14, 2.11] \\ \pi_1^{\{1, 1, 1, 1\}}, & \text{otherwise} \end{cases}$$

Similar analysis can be carried out for other subgames. In what follows, we will report only the equilibrium choices in each subgame and omit most of the payoff expressions.

(2) The subgame $1d$

- (i) If $2s$, the equilibrium is the same as that in subgame $1s2d$, namely $3s4s$.
- (ii) If $2d$, then $3s \rightarrow 4s$ and $3d \rightarrow 4s$. Between $3d$ and $3s$, 3 always chooses $3s$. 4 will reject the $3 + 4$ offer. The equilibrium in subgame $1d2d$ is therefore $3s4s$.
- (iii) If $2m$, then

- If 3 accepts, then $4d$ for $b \in [1.09, 2.41]$ and $4s$ otherwise.
- If 3 rejects, then $2s3s4s$.
- 3's optimal choice is to reject the $2 + 3$ proposal.

(iv) The equilibrium in subgame $1d$ is $2s3s4s$. Firm 1's payoff in subgame $1d$ is therefore

$$d_1 = 2\pi_{\frac{1}{2}}^{\{\frac{1}{2}, \frac{1}{2}, 1, 1\}} - f_d.$$

(3) The subgame $1m$

(i) If 2 accepts:

- If $3s$, then $4d$ for $b \in [1.13, 2.71]$ and $4s$ otherwise.
- If $3d$, then $4d$ for $b \in [1.09, 2.41]$ and $4s$ otherwise.
- If $3m$, then: if 4 rejects, then $3d4d$ for $b \in [1.13, 2.41]$, $3d4s$ for $b \in [2.41, 2.71]$, and $3s4s$ otherwise. 4's optimal choice is to accept the $3+4$ offer for $b \in [1.13, 2.71]$, and reject the offer otherwise.
- Firm 3's optimal choice is $3m$ for $b \in [1.13, 2.41]$, $3d$ for $b \in [2.41, 2.71]$, and $3s$ otherwise. As a result, if 2 accepts $1 + 2$, the equilibrium will be $3 + 4$ for $b \in [1.13, 2.41]$, $3d4s$ for $b \in [2.41, 2.71]$, and $3s4s$ otherwise.

(ii) If 2 rejects, then $1d2s3s4s$ for $b \in [1.14, 2.11]$ and $1s2s3s4s$ otherwise.

(iii) Facing the proposal $1 + 2$, 2's optimal choice is to accept the offer for $b \in [1.13, 2.41]$ and to reject it otherwise. As a result, firm 1's payoff in the subgame $1m$ is

$$m_1 = \frac{1}{2}\pi_2^{\{2,2\}} - f_m \text{ for } b \in [1.13, 2.41].$$

(4) Finally, a comparison between m_1 , n_1 and d_1 reveals that firm 1's optimal choice is $1m$ for $b \in [1.13, 2.41]$ and $1s$ otherwise. As a result, the equilibrium for the whole game is: $(1 + 2) \rightarrow (3 + 4)$ for $b \in [1.13, 2.41]$ and $1s2s3s4s$ otherwise.

Two more examples for $n = 4$ and $t_i = 1$

For notational brevity, we let s (for stand alone) denote independence, d divestiture, and $i + j$ the merger between firms i and j .

Example 2: If $f_d = 0.005$, $1d2s3s4s$ for $b \in [0.86, 0.88]$, $1d2d3s4s$ for $b \in [0.88, 0.90]$, $(1 + 2)(3 + 4)$ for $b \in [0.90, 3.20]$, and all four firms remain independent for other values of b . The force behind the merger wave, with an even wider range of b , is the same as in previous cases. To the left of this range, however, there is now room for one or two divestitures. This is because at this low value of f_d , the 1,2 merger will weaken rather than strengthen firm 4's incentive to divest, which means the 3,4 merger cannot be induced, which in turn means 1 and 2 will not merge.

Example 3: If $f_d = 0.004$, the equilibrium is even richer: $1s(2 + 3)4s$ for $b \in [0.59, 0.64]$, $(1 + 2)(3 + 4)$ for $b \in [0.64, 1.83]$, $1d2d3d4d$ for $b \in [1.83, 2.63]$, $1d2d3d4s$ for $b \in [2.63, 3.21]$, $1d2d3s4s$ for $b \in [3.21, 3.93]$, $1d2s3s4s$ for $b \in [3.93, 4.76]$, and all firms remain independent otherwise. In previous cases, the threat of both 3 and 4 divesting was enough to force them to merge. When f_d is low, however, divestiture may not be so bad, and firms 3 and 4 may both choose to divest. As a result, the 3,4 merger can be induced only over a smaller range of b . To the right of that range (i.e., when b is larger), a series of divestitures takes place. Depending on the value of b , there may be one, two, three or even four divestitures. When there are at least two divestitures, all four firms suffer—each firm's payoff is lower than when all of them remain independent.³⁶

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³⁶The equilibrium has a flavor of the Prisoners' Dilemma even though the game is sequential. For example, in the equilibrium in which all four firms divest, no matter what a firm does, later firms always divest. Anticipating that, an early mover will choose to divest. In that sense, we may say that divestiture is the dominant strategy for each firm. Such a dominant strategy is mutually damaging, however—each firm would have earned a higher payoff if all four firms had remained independent.

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