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Mergers in Multidimensional Competition

by

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Abstract

In reality, horizontal mergers are often driven by the opportunities they create for the exploitation of R&D complementarities. An example is the BP/ ARCO mega-merger, approved in 2000, where a central justification was that integration – by committing the firms to sharing their accumulated technical expertise – would significantly reduce extraction costs at the enormous Prudhoe Bay oil field in Alaska. We investigate the positive features of a prior bilateral merger to exploit R&D complementarities in a game where oligopolists compete both in process R&D and on the product market. For a non-trivial degree of complementarity between firms' R&D stocks, we show that a bilateral merger has the following intuitively-appealing features independently of the assumed strategic variable in market competition (price vs. quantity): (a) insiders benefit; (b) outsiders are harmed; and (c) insiders end up larger than outsiders. These results represent a significant advance on the findings of traditional models of merger to achieve market power alone, which are well known to be both counterintuitive and highly sensitive to the (unobservable) mode of product market competition.

JEL classification: L11, L41, O31.

Keywords: horizontal merger; R&D complementarities; endogenous R&D; merger paradox.

Outline

1. *Introduction*
2. *Quantity Competition*
3. *Price Competition*
4. *Conclusion*

Non-Technical Summary

The motivation for our analysis is the empirical proposition that horizontal mergers are often motivated by a desire to exploit complementarities between the participants' R&D stocks. The merger in 2000 between BP and ARCO, which was justified on the grounds that the resulting pooling of technical knowledge would significantly reduce oil extraction costs, provides a solid example of this mechanism. We study the equilibrium outcomes of multidimensional competition, where firms compete in process R&D and then on the product market, and the positive effects of a prior bilateral merger. Our modelling structure incorporated two distinct motives for merger: first, a traditional "market power" (or "strategic") motive; and second, a novel "R&D pooling" motive to reflect the empirical driver of mergers noted above: a merged firm can apply the process R&D conducted on one inside brand to the production of the merger-partner's brand, thereby exploiting the "public good" nature of R&D output to generate extra process innovations from given R&D stocks. The game was solved backwards, generating predictions for the effects of merger on both process R&D investments and product market actions. In particular, because R&D investments are endogenously determined and merger allows R&D complementarities to be exploited, our model can be interpreted as providing an account of the size of the "synergy" benefits of merger.

Our most significant results occur whenever the degree of R&D complementarity between brands is non-trivial. In this case, relative to the (symmetric) no-merger equilibrium, a bilateral merger has the following positive properties: (a) insiders (i.e. merger participants) benefit; (b) outsiders (i.e. non-participants) are harmed; and (c) insiders end up larger than outsiders. We describe the conjunction of these three features as the "Intuitive Outcome" because it accords with our basic intuition on the effects of merger. The mechanism behind these results is that a non-trivial degree of R&D complementarity simultaneously encourages extra process R&D investment by the insiders and, by toughening competition on the product market, discourages R&D spending by the outsiders. Importantly, we obtain these intuitively-appealing results *independently of the strategic variable in market competition* (price vs. quantity). This represents a significant advance on the findings of existing models of merger to achieve market power alone, which are well known to be both extremely counterintuitive and highly sensitive to the assumed mode of product market competition. In contrast, the strategic variable in market competition, an unobservable characteristic of real-world product markets, plays no role in our central qualitative results.

1. Introduction

A key feature of the results of R&D investment is their “public good” (i.e. non-rival) aspect both within and across firms: use of a new technology in one plant does nothing to preclude its application to production elsewhere. Indeed, the total return to an R&D investment is (in general) greater, the more widely its results are disseminated across production plants.¹ The corporate structure of British Petroleum Amoco (BP), the world’s second-largest integrated oil company, clearly reveals the profitability gains from information pooling and the role played by integration in facilitating it: BP comprises around 100 semi-autonomous business units, which are encouraged to share information extensively through “peer assists” (i.e. business units can call on personnel from other units to help solve operating problems).² More specifically, it appears that, in the real world, horizontal mergers are often driven by the opportunities they create (via knowledge transfers between plants) for the exploitation of R&D complementarities. The experience of BP again illustrates this: a central justification for the BP/Atlantic Richmond (ARCO) mega-merger, approved by the Federal Trade Commission in 2000, was that – by committing the firms to sharing their accumulated technical expertise – it would significantly reduce extraction costs at the enormous Prudhoe Bay oil field in Alaska.³

Using a framework of “multidimensional” (i.e. two-stage) competition where firms compete both in process R&D and on the product market, this paper analyses the use of

¹ Although a given firm will be harmed if a rival accesses its stock of process R&D (and firms’ R&D stocks are not perfect substitutes), joint profits rise as the “general level” of marginal costs falls. (This simple point takes R&D stocks as given. The important issue of the impact of the scope of dissemination on R&D investment incentives is discussed below.)

² That BP maintains extremely lean headquarters is evidence of the operational discretion granted to its constituent “business units.” See Holmström and Roberts (1998, p. 91) for more on the BP case and other relevant examples.

³ BP and ARCO persuasively argued that over twenty years of contractual experiments to gain the benefits of information pooling had failed (see Bulow and Shapiro, 2002; Farrell and Shapiro, 2001, p. 705). The Farrell/Shapiro article (pp. 705-8) gives other examples of mergers to exploit R&D complementarities. Moreover, it is well established in the empirical literature that “synergies” from combining firms’ R&D stocks can motivate merger (Andrade, Mitchell and Stafford, 2001).

horizontal mergers to exploit R&D complementarities between firms. A key contribution is that the size of the synergy benefit of merger, caused by the existence of R&D complementarities, is endogenously determined. We are primarily concerned with the conditions under which such arrangements are profitable for the participating (“inside”) firms and with the implications of mergers motivated by the existence of R&D complementarities for the relative position of non-participating (“outside”) firms.

Despite the apparently widespread use of horizontal merger to exploit complementarities in firms’ R&D stocks, the formal literature on “R&D pooling” has focused almost exclusively on the vehicle of research joint ventures (RJVs) whereby firms decide to share technological knowledge while, in principle, continuing to compete against each other in the product market.⁴ In addition to their empirical relevance, we justify our focus on horizontal mergers because, in many cases, RJVs may prove impossible to form, forcing firms to search for other methods of exploiting R&D complementarities. For example, firms participating in an RJV clearly have a strong incentive not to reveal all their R&D results to their partners. If an RJV is to achieve different results from thoroughgoing non-cooperative behavior, this problem must be overcome. In principle, a solution is for the participants to contract out all R&D activities to a third party; however, in practice, contracts are likely to be prohibitively costly to establish and enforce. In such cases, horizontal merger, which precommits participating firms to sharing all their R&D

⁴ Using a two-stage model of process R&D followed by product market interaction, Kamien, Muller and Zang (1992) provide a thorough analysis of RJVs, contrasting the cases of “RJV competition” (firms pool R&D results but behave non-cooperatively at both stages) and “RJV cartelization” (pooling of R&D results with cooperative determination of R&D investment but competition in the subsequent market stage). Suzumura (1992) contains a closely related analysis. D’Aspremont and Jacquemin (1988) do allow for merger (i.e. participating firms pool R&D results and cooperate in both stages of the game); however, as with Kamien/ Muller/ Zang, all firms in the industry (two, in their case) are assumed to participate, which makes an assessment of the relative position of “insiders” versus “outsiders”, a key contribution of our analysis, impossible. For analyses of the converse case to RJV, where all firms *compete* in R&D but then *collude* in outputs, see Fershtman and Gandal (1994) and Brod and Shivakumar (1999).

outputs with all other insiders (joint profit maximization), will be an attractive alternative to forming an RJV.^{5,6}

We model horizontal mergers motivated by the exploitation of R&D complementarities in a two-stage game played by oligopolistic firms, each producing a substitute brand of a differentiated good. In the first stage the firms choose how much to invest in process R&D, and in the second stage they compete on the product market. We solve the game backwards to isolate its sub-game perfect Nash equilibrium in pure strategies. Aside from our modeling of R&D complementarities, our set-up is standard to allow for straightforward comparisons with the existing formal literature.⁷ The marginal cost of a firm that is not merged with another depends only on its own R&D investment (i.e. there are no inter-firm spillovers). However, a merged firm's marginal cost is decreasing both in its own R&D level and (at a slower rate) in the combined R&D spending of other insiders. (We restrict attention to a single bilateral merger, where two firms co-operate in both the R&D and production stages.⁸) Therefore, R&D complementarities are reflected in the fact that a merged firm's "effective" R&D stock is a weighted sum of its own R&D spending and that of the other insider; this is the "synergy" effect of merger. The weight on the merger partner's R&D spending (i.e. the degree of R&D complementarity) depends on the "technical closeness" between brands. If production processes

⁵ See Hernán, Marín and Siotis (2003) for an empirical assessment of determinants of firm participation in RJVs. Note also that "asymmetric" RJVs (e.g. where one participant undertakes the bulk of R&D activity) are likely to be much more difficult to establish than "symmetric" ones (identical participants) because financial transfers to the R&D-intensive insider from its partners will be necessary (to ensure that all firms benefit from the RJV). The dilemma is that the partners will be unwilling to contribute much towards the innovating firm's R&D budget until the quality of its new R&D results has been verified; however, verification may require distributing the new technology amongst insiders for free. Repeated interactions and contracting may help to alleviate this problem, but in many cases integration will prove a more straightforward alternative.

⁶ It should be noted that the RJV/ merger comparison is only likely to be interesting under Cournot competition, since mergers are generally profitably under Bertrand for "market power" reasons alone.

⁷ Marginal costs are constant and decreasing in R&D at a constant rate. The marginal cost of R&D is strictly increasing. The system of demand functions is symmetric and linear. We allow for both Cournot and Bertrand competition in stage two.

⁸ This can be justified by assuming, for example, that the sunk cost of administering a merger is strictly convex and increasing in the number of participating firms.

are quite similar (e.g. because brands are only distinguished by some non-technical attribute such as color), then we would expect a merged firm's effective R&D stock to be approximately the unweighted sum of both insiders' spending on R&D. On the other hand, if production processes are quite heterogeneous (e.g. because quite different machinery is used to produce different brands), then we would expect an insider's effective R&D stock approximately to equal its own R&D spending.⁹

Our results stem from a comparison between the game's (sub-game perfect) Nash equilibria with and without a bilateral merger. They can be interpreted in relation to the findings of the canonical analyses of horizontal mergers under Cournot competition (Salant, Switzer and Reynolds, 1983) and Bertrand competition (Deneckere and Davidson, 1985), both of which took firms' marginal costs as identical and exogenously given. Moreover, a key contribution of our modeling approach, the novelty of which is that mergers affect competition in two "dimensions" (i.e. in R&D and on the product market), is that it permits a solution to the well-known "merger paradox." The "merger paradox" refers to the difficulty of constructing a model of horizontal mergers where (a) insiders generally gain; (b) outsiders generally lose; and (c) insiders are larger (in sales terms) than outsiders in the post-merger equilibrium. We regard (a), (b) and (c) as intuitively-appealing properties that any "reasonable" model of horizontal mergers should be capable of satisfying. Properties (a) and (b) seem desirable because, in reality, mergers are both frequently proposed by firms and invariably fiercely opposed by outsiders. We

⁹ Two implicit assumptions should be recognized. First, we assume that the similarity between firms' R&D activities is independent of that between their production processes (i.e. the "technical closeness" between brands). (If firms with identical production processes undertook identical R&D activities with identical results, then there would obviously be no advantage from pooling R&D results.) This follows the Kamien/ Muller/ Zang (1992, p. 1298) assumption that R&D activity involves trial and error ("it is a multidimensional heuristic rather than a one-dimensional algorithmic process") with each firm pursuing several avenues of research simultaneously, only some of which pay off. Second, we assume that the differentiation between brands in the eyes of consumers is independent of the "technical closeness" between brands' production processes: seemingly identical brands may be produced very differently.

advocate (*c*) because, as Perry and Porter (1985, p. 219) argue, it seems right that a merger, by pooling the insiders' assets, should make the integrated firm "larger" than its rivals. Unfortunately, when firms compete in only one "dimension" (i.e. on the product market), models of horizontal mergers under both Cournot and Bertrand competition have been unable simultaneously to satisfy criteria (*a*), (*b*) and (*c*).¹⁰ In particular, while insiders generally lose from merger under Cournot competition, under Bertrand they generally gain. These converse profitability effects for insiders are particularly troubling because they hinge on an unobservable characteristic of the market, the strategic variable in competition.

To gain an intuitive feeling for our results on the profitability effects of merger, consider how a merger affects the market equilibrium in stage two *ceteris paribus*. For a given distribution of R&D spending across brands, a merger exerts two opposing influences on the insiders' behavior in market competition. First, the traditional "market power" (or "strategic") effect reflects the insiders' attempts to move towards the monopoly solution. As is well known, under both Cournot and Bertrand competition, the market power effect makes the insiders less aggressive.¹¹ The second effect of merger on market competition, which works in the opposite direction, is the "R&D pooling" effect. Under both Cournot and Bertrand behaviour, this makes

¹⁰ That represents the record rather euphemistically. In fact, under Cournot competition (Salant, Switzer and Reynolds, 1983) (*a*), (*b*) and (*c*) all fail, whereas under Bertrand competition (Deneckere and Davidson 1985) only (*a*) holds. Gowrisankaran (1999) also examines the relationship between horizontal merger and R&D investment; however, his focus (the development of an endogenous merger process across all firms) is quite different from ours and, consequently, our modelling of R&D activity is richer. In particular, in Gowrisankaran's framework, a merged firm is constrained to operate only one R&D lab, so the effects of the pooling of insiders' R&D outputs within the merged firm cannot be examined. Moreover, Gowrisankaran's results suggest that, by leading to a reduction in R&D investment, merger reduces the size of insiders on the product market and benefits outsiders (although the effect on outsiders is not explicitly considered). In Perry and Porter (1985) horizontal merger leads to the agglomeration of a "specific factor" within the merged firm and a fall in its marginal cost. However, because the initial distribution of the specific factor across firms is exogenous, the size of the merged-induced fall in marginal cost is not explained. (For a very different approach to the merger paradox that also happens to rely on information sharing within the merged firm, see Creane and Davidson, 2004 and Huck, Konrad and Mueller, 2004).

¹¹ Put differently, the market power effect shifts the insiders' combined best reply function inwards in quantity space (Cournot), but it shifts each insider's best reply function upwards in price space (Bertrand). Both shifts reflect insiders' wishes to move up their brand demand functions towards the monopoly solution.

the insiders more aggressive as they exploit R&D complementarities (between given R&D stocks) and their marginal costs fall. Which of the two effects dominates, and the consequent net direction of shift in the insiders' best reply functions, is determined by the degree of technical closeness between brands (i.e. R&D complementarity), which governs the strength of the R&D pooling effect relative to the market power effect.

In our "linear" model, quantities are strategic substitutes under Cournot competition but prices are strategic complements under Bertrand. Therefore, under Bertrand competition, the R&D pooling effect benefits insiders but harms outsiders, whereas the market power effect benefits both types. Because both effects benefit insiders under Bertrand competition, the only question is whether outsiders gain or lose from merger. For low levels of technical closeness (R&D complementarity), the market power effect dominates, so all firms gain from merger; we label this the "Pareto Gain" case. As brands become technically closer (i.e. the degree of R&D complementarity rises), the R&D pooling effect strengthens relative to the market power effect. Eventually, for sufficiently technically close brands, the R&D pooling effect dominates, so insiders gain from merger but outsiders lose; we label this the "Intuitive Outcome."¹²

The profitability effects of merger are more complex under Cournot competition because the insiders do not always gain. As with Bertrand, the R&D pooling effect benefits insiders but harms outsiders under Cournot competition. However, the market power effect now works in precisely the opposite direction, harming insiders but benefiting outsiders. The polar cases, where one of the two effects of merger on market equilibrium obviously dominates, are clear: for low levels of technical closeness, the market power effect dominates and insiders lose from merger but outsiders gain, the "Salant, Switzer and Reynolds" case; and for sufficiently

¹² Moreover, we show that the critical degree of technical closeness that makes outsiders indifferent to a merger is very small under Bertrand competition, so the "Intuitive Outcome" occurs for most of parameter space.

technically close brands, the R&D pooling effect dominates and insiders gain from merger but outsiders lose, the “Intuitive Outcome” again. In between, for intermediate levels of technical closeness (R&D complementarity), the market power and R&D pooling effects are of “roughly equal” strength, and all firms gain from merger, the “Pareto Gain” outcome repeated.¹³

Our central result on the profitability effects of merger is that, for sufficiently technically close brands, bilateral mergers in multidimensional competition benefit the insiders but harm outsiders *independently of the strategic variable in market competition*. We refer to a post-merger equilibrium with these features as the “Intuitive Outcome” because it fulfils “reasonable criteria” (a) and (b) introduced above. The largeness of the areas in both strategy and parameter space over which our model generates the “Intuitive Outcome” becomes a particularly valuable feature when contrasted with the profitability effects generated by “traditional” models of merger to achieve market power alone, which are well known to be both counterintuitive and highly sensitive to the (unobservable) mode of product market competition.

Our results on the implications of merger for firm size can be understood by considering the determination of process R&D levels in stage one. The profitability of extra R&D investment depends on the size of the resulting process innovation and on the level of output to which that innovation will be applied in production. A merger does not alter the relationship between R&D investment and cost reduction for outsiders, but it enhances the efficiency of R&D investment for insiders because both own-brand and merger-partner marginal costs are reduced. The effect of merger on firm outputs follows from the discussion above of profitability effects. In sales volume terms, the greater the degree of technical closeness between brands, the

¹³ Under Cournot competition, there are two critical levels of technical closeness to consider, one to make insiders indifferent to merger and a second for outsiders. It is impossible for them to be ranked such that, for some parameters, all firms lose from merger. Intuitively, since merger reduces “competition” in the industry, average firm profits rise.

larger will be insiders relative to outsiders in product market equilibrium (because the stronger will be the R&D pooling effect relative to the market power effect).¹⁴ This feature is independent of the choice between Cournot and Bertrand competition.¹⁵ These output effects of merger mean that an insider's R&D incentive (marginal return) is increasing in the degree of technical closeness between brands, while that for outsiders is decreasing.¹⁶ Therefore, for inside brands, the volumes of both process R&D and output are increasing in technical closeness, whereas both are decreasing in technical closeness for outside brands.¹⁷ This gives our final key result, the conditions under which “reasonable criterion” (*c*) are satisfied: independently of the strategic variable in market competition, insiders are larger than outsiders in post-merger equilibrium for sufficiently technically close brands. Furthermore, combining this result with our findings on the profitability effects of merger, our modeling structure is capable simultaneously of fulfilling all our “reasonable criteria” (i.e. profitable mergers; harmed outsiders; and insiders larger than outsiders) under both Cournot and Bertrand competition when brands are sufficiently technically close.

The remainder of the paper is organized as follows. In the next two sections we solve for the equilibrium outcomes of multidimensional competition under, successively, Cournot and Bertrand competition in the market stage. We pay particular attention to cataloguing the

¹⁴ Moreover, assume that R&D per brand is at its (symmetric) equilibrium level with no merger. Then, relative to the no-merger equilibrium outputs, a merger decreases (increases) insiders' production but increases (decreases) that of outsiders for low (high) degrees of technical closeness.

¹⁵ In Cournot competition increased technical closeness raises insider output and cuts outsider output (strategic substitution), while under Bertrand it reduces the relative price of insiders (i.e. all prices fall due to strategic complementarity but outsiders do not respond equiproportionately to insiders' price cuts).

¹⁶ Of course, merger also enhances the insiders' R&D incentives by permitting the public good characteristic of R&D output to be exploited.

¹⁷ We show that, for a non-trivial degree of technical closeness between brands, the R&D pooling effect and an increased level of R&D investment work together to increase the size (output volume) of insiders following merger. Moreover, following merger, both inside and outside firms optimally choose the (symmetric) equilibrium no-merger R&D level for “interior” degrees of technical closeness.

profitability effects of merger by comparing the no-merger and post-merger equilibria. Finally, section 4 concludes.

2. Quantity Competition

We consider a market populated by N initially identical firms that compete in two-stages of competition. In the first stage, they invest in R&D which lowers their marginal cost of production. In the second stage, once marginal costs have been determined and revealed, they compete in quantities. We first calculate the equilibrium outcome under the assumption that the firms remain independent and then compare this with the outcome generated when firms 1 and 2 merge before stage 1 competition begins.

We assume that market demand is linear with

$$(1) \quad p_i = A - q_i - \beta q_{-i}$$

where p_i and q_i denote firm i 's price and output, respectively, and $q_{-i} \equiv \sum_{j \neq i} q_j$. Without investment in R&D, we assume that each firm would face a constant marginal cost of c . Furthermore, in the absence of a merger, any firm that spends x_i on R&D can lower its marginal cost to $c - x_i$, so that there are no inter-firm spillovers from R&D. Firm i 's total cost of R&D is assumed to be $(\gamma/2)x_i^2$.

If a merger between firms 1 and 2 takes place, then there are two implications. First, the merged firms choose R&D and output levels to maximize their joint profits. Second, the merged firms share the results of their research and this generates within-firm spillover effects. In particular, we assume that the firms' marginal costs become $c_1 = c - x_1 - \theta x_2$ and $c_2 = c - x_2 - \theta x_1$ where θ measures the degree of *technical closeness* between brands, which

determines the magnitude of within-firm spillovers following merger. The basic idea that we are trying to capture is that the bilateral merger enables the integrated firm to exploit the technical closeness between brands by applying R&D conducted on one brand to the production process of the other brand it owns. The magnitude of θ therefore depends upon the technical closeness of the brands offered by the two firms. For example, if the production processes are quite heterogeneous (e.g., different machinery is used to produce the different brands) then we would expect θ to be quite small. On the other hand, if the production processes are quite similar (so that the brands are distinguished by some non-technical attribute such as color), then we would expect R&D activity to generate considerable (within-firm) spillovers.

We begin by describing the Sub-game Perfect Nash Equilibrium (SPNE) in the absence of the merger. To simplify the exposition that follows, we introduce the following notation: $Q \equiv \sum_i q_i$; $C \equiv \sum_i c_i$; $\Delta_0 \equiv 2 + \beta(N-1)$; and $\Delta_1 \equiv \Delta_0 - \beta^2$. Then, in the second stage of the game, firm i 's goal is to choose output, q_i , to maximize profits from sales with R&D expenditures held fixed; or,

$$(2) \quad \max q_i \left[A - q_i - \beta \sum_{j \neq i} q_j - c_i \right]$$

with $c_i = c - x_i$ and x_i fixed. Straightforward calculations yield the following symmetric stage two equilibrium outcomes

$$(3) \quad q_i = \frac{(2 - \beta)A + \beta C - \Delta_0 c_i}{(2 - \beta)\Delta_0} \quad \forall i$$

$$(4) \quad Q \equiv \frac{AN - C}{\Delta_0}$$

Turn next to stage one in which the firms independently choose their R&D levels. For firm i , the goal is to choose x_i to maximize profits; or,

$$(5) \quad \max \quad q_i \left[A - q_i - \beta \sum_{j \neq i} q_j - (c - x_i) \right] - \frac{\gamma}{2} x_i^2$$

where q_i and q_j are given in (3). Carrying out the maximization and applying symmetry yields the following equilibrium outcome:

$$(6) \quad x_i = \frac{2(\Delta_0 - \beta)(A - c)}{(2 - \beta)\gamma\Delta_0^2 - 2(\Delta_0 - \beta)} \quad \forall i$$

Profits can then be obtained by substituting (6) into (3) and then using the fact that, at Cournot equilibrium,

$$(7) \quad \pi_i = q_i^2 - .5\gamma x_i^2.$$

For (3), (6) and (7) to represent an equilibrium, it must be the case that $\gamma > 2 \left[\frac{\Delta_0 - \beta}{(2 - \beta)\Delta_0} \right]^2$ and

$c > \frac{2A(\Delta_0 - \beta)}{(2 - \beta)\gamma\Delta_0^2 - 2(\Delta_0 - \beta) + 1}$. The first inequality ensures that the firms' second-order-

conditions hold and the second inequality ensures that (6) is compatible with non-negative marginal costs.

Now, suppose that firms 1 and 2 merge prior to the stage 1 competition. Then in stage 2, the outsiders still solve (2) while the insiders choose q_1 and q_2 to solve

$$(8) \quad \max \quad q_1 \left[A - q_1 - \beta q_2 - \beta \sum_{j>2} q_j - c_1 \right] + q_2 \left[A - q_2 - \beta q_1 - \beta \sum_{j>2} q_j - c_2 \right]$$

Carrying out the maximization and solving the first-order conditions yields the following stage 2 outcomes

$$(9) \quad q_1 + q_2 = \frac{(2 - \beta)A + \beta C - .5\Delta_0(c_1 + c_2)}{\Delta_1}$$

$$(10) \quad q_i = \frac{(2 - \beta)A + \beta C - \Delta_1 c_i - .5\beta^2(c_1 + c_2)}{(2 - \beta)\Delta_1} \quad \forall i > 2$$

$$(11) \quad Q = \frac{(N - \beta)A - C + .5\beta(c_1 + c_2)}{\Delta_1}$$

Turn next to the first stage in which the firms compete in R&D. Since R&D now creates spillovers for the insiders, the marginal costs for the firms become

$$(12) \quad c_1 = c - x_1 - \theta x_2; \quad c_2 = c - x_2 - \theta x_1; \quad \text{and} \quad c_i = c - x_i \quad \forall i > 2$$

Each outsider chooses x_i to maximize (7) with the outputs given in (9) and (10) and the costs given by (12); whereas the insiders choose x_1 and x_2 to maximize joint profits, or

$$(13) \quad \pi_1 + \pi_2 = q_1^2 + q_2^2 + 2\beta q_1 q_2 - .5\gamma(x_1^2 + x_2^2)$$

If we use x_m to denote the R&D choice of each firm involved in the merger and use x_o to denote the choice by a typical outsider, then carrying out the maximization, applying symmetry for insiders ($x_m \equiv x_1 = x_2$) and outsiders ($x_o \equiv x_i$ for all $i > 2$), and solving yields

$$(14) \quad x_m = \frac{(a_3 b_1 - a_1 b_2)(A - c)}{a_3 b_3 - a_2 b_2}$$

$$(15) \quad x_o = \frac{a_1(A - c) - a_2 x_m}{a_3}$$

where we have defined $a_1 \equiv 2(\Delta_1 - \beta)$; $a_2 \equiv a_1\beta(1 + \theta)$; $a_3 \equiv \gamma(2 - \beta)\Delta_1^2 - a_1(1 + \beta)$;

$b_1 \equiv (1 + \beta)(2 - \beta)(1 + \theta)(\Delta_0 - 2\beta)$; $b_2 \equiv \beta(1 + \beta)(1 + \theta)(N - 2)(\Delta_0 - 2\beta)$; and

$b_3 \equiv 2\gamma\Delta_1^2 - (1 + \beta)(1 + \theta)^2(\Delta_0 - 2\beta)^2$. Equilibrium profits for the outsiders can then be

calculated by substituting (10), (12), (14), and (15) into (7). Similarly, equilibrium profits for the merged firm can be obtained from (9) and (12)-(15).

Our results are summarized in Figure 1 where the parameter space is divided into 3 regions. The degree of product differentiation (β) is measured on the horizontal axis, with a value of zero representing independent goods and a value of one representing perfect substitutability across brands. The level of merger-induced R&D spillovers is measured on the vertical axis, with higher values indicating stronger complementarities in R&D across the merged firm's brands. The curve labeled $\theta_M(\beta)$ shows combinations of β and θ for which the *insiders* earn the same profits with and without the merger. Thus, below this curve the R&D spillovers are not strong enough to generate gains for the insiders. The curve labeled $\theta_O(\beta)$ shows combinations of β and θ for which the *outsiders* earn the same profits with and without the merger. Above this curve, the R&D spillovers for the merged firm are strong enough that the outsiders are harmed by the merger. It follows that in the region labeled SRR, we get the standard Salant, Switzer and Reynolds (1983) result: the insiders are harmed by the merger while the outsiders gain. In the region labeled PG (for Pareto Gain), both the insiders and the outsiders benefit from the merger.¹⁸ Finally, in the region labeled IO (for Intuitive Outcome), we find that the insiders gain from the merger while the outsiders are harmed.

The forces that generate our results can be explained with the aid of Figure 2, which shows the aggregate output produced by the insiders (Q_m^*) and the outsiders (Q_o^*) in the second stage of the game. Of course, since quantities are strategic substitutes, these values vary

¹⁸ This region could be sub-divided based on whether the insiders or the outsiders gain more. In the lower portion of the PG region, the outsiders gain more; yielding an outcome qualitatively identical to that obtained in Deneckere and Davidson's (1985) study of mergers with price competition. Thus, with two-dimensional competition, it is possible to get the Deneckere-Davidson outcome when firms compete in quantities. In the upper-portion of the PG region, it is the insiders that benefit more from the merger than the outsiders.

inversely with each other. The solid black lines represent best-response outputs in the absence of the merger, so that the no-merger Nash equilibrium is represented by their intersection. We begin by focusing on the insiders' output choice in the second stage of competition, holding brand R&D levels fixed at the equilibrium no-merger level. When the insiders merge, it is in their collective interest to produce less output than they would in the absence of the merger in order to push price up towards its collusive level – thus, their total output would be lower than it would be without merger. This change in behavior is reflected by the downward shift of the Q_m^* curve to the dashed red line in Figure 2. Since best-reply functions are downward sloping under quantity-competition, this shift results in higher aggregate output by the outsiders. As a result, the merger leaves the insiders with a lower market share and a (slightly) higher price; but, because the increase in price is dampened by the expansion of the outsiders, the insiders typically lose. On the other hand, the outsiders wind up selling more output at a higher price, so that they always gain. This is the traditional *market power effect* of a horizontal merger that drives the results in Salant, Switzer and Reynolds (1983) – the merger causes the insiders to produce less. This usually harms the insiders while benefiting the outsiders.

In addition to the market power effect, there is another force at work that alters the outcome in the second stage. Since the merger generates R&D spillovers for the insiders, if we hold the firms' R&D investments at their no-merger levels, then the merger lowers the marginal costs of the insiders (as the insiders' R&D stocks are pooled within the merged firm). This shifts up their best reply function toward the blue dashed line in Figure 2, tending to increase insider output but to cut that by outsiders. We refer to this change in behavior due to R&D pooling by the insiders as the *R&D pooling effect*. Which of the market power and R&D pooling effects dominates, and the consequent net direction of shift in the insiders' best reply

function, is determined by the degree of technical closeness between brands θ , which governs the relative strength of the R&D pooling effect.

Now, turn to the first stage of competition. The impact of the merger on R&D spending by the insiders is not obvious. The profitability of extra R&D investment depends both on the size of the resulting process innovation and on the level of output to which that innovation will be applied in production. On the one hand, since the merger creates spillovers in R&D for the insiders (i.e. a “larger” process innovation), there is an incentive for the insiders to spend more on R&D following the merger than they would in its absence. This is the *synergy effect* of merger on R&D investment, which results from the pooling of the insiders’ R&D stocks following merger. On the other hand, for a given level of brand R&D spending, the impact of merger on insiders’ output is ambiguous and depends upon which of the market power and R&D pooling effects dominates in stage 2.

When merger-induced R&D spillovers are very weak, merger works to reduce the output of inside brands (i.e. the market power effect dominates the R&D pooling effect in stage 2), and this effect itself outweighs the (weak) synergy effect so that the marginal return to R&D for insiders falls and merger leads to a reduction in R&D spending by the insiders. As the level of merger-induced R&D spillovers rises, the market power effect in stage 2 weakens relative to the R&D pooling effect so that insiders’ output (for given R&D investments) tends to rise following merger. By itself, expanding output makes extra R&D investment profitable, and this tendency is reinforced by a strengthening of the synergy effect as θ rises. Therefore, only modest spillovers are required for merger to raise the marginal return to insiders of R&D investment, implying that for most values of θ , the merger leads the insiders to spend more on R&D than they would otherwise. Increased R&D investment leads to lower marginal costs for all insiders

and reinforces the R&D pooling effect in stage 2, shifting the insiders' best reply function in Figure 2 up to the dashed blue line.¹⁹ We refer to changes in behavior due to changes in the first stage of competition as the *R&D investment effect*. Note that, as long as merger permits a non-trivial degree of R&D spillovers, the R&D pooling and R&D investment effects work in the same direction – they both make the insiders more aggressive and shift up their combined best reply function. For future reference, we refer to the combination of these two as the total *R&D effect* of the merger. If the R&D effect were the only impact of the merger, the insiders would end up producing more, the outsiders would end up producing less, the insiders would gain, and the outsiders would lose. It follows that the R&D effect works in the opposite direction to the traditional market power effect – it causes the insiders' aggregate output to increase. This benefits the insiders while harming the outsiders.

When the goods are almost independent (i.e., when β is low) the market power effect of merger is weak and it only takes a low level of R&D spillovers for the R&D effect to dominate. When this occurs, we have the Intuitive Outcome. As β increases (i.e., the goods become more similar), the market power effect becomes more important and a higher value of θ is required to generate the Intuitive Outcome.

When R&D spillovers are weak (i.e., θ is low), then the market power effect dominates for even low values of β and we have the standard SSR outcome. However, as θ increases, the R&D effect becomes more important and a higher value of β is then needed for the market power effect to dominate. For intermediate values of θ and β , the two effects roughly balance out and all firms benefit from the merger. In this case, the outsiders benefit because the market power effect makes the insiders collectively less aggressive when choosing their output levels;

¹⁹ Moreover, even if the insiders respond to the merger by reducing R&D expenditures, their marginal costs are still likely to be reduced by the merger-induced R&D spillovers.

whereas the insiders benefit because the R&D effect results in greater R&D spending and lower marginal costs of production.

The curves in Figure 1 correspond to the case in which there are 10 firms in the industry. If there are fewer firms, then, holding all else equal, a bilateral merger generates larger positive benefits for the outsiders, implying that strong R&D spillovers for the insiders are required to make the outsiders indifferent towards the merger. Thus, as N falls, the $\theta_o(\beta)$ curve shifts up. As for the insiders, as N falls, a bilateral merger is more likely to be profitable solely for market power reasons (there are fewer outsiders to increase output in response to the merger). Thus, as N falls, the $\theta_M(\beta)$ curve shifts to the right. As a result, for low values of N , the PG region is quite large. This region shrinks as N increases, with the SSR and IO regions becoming larger.

In multidimensional competition where product market interaction is Cournot, we have shown that some firms in an industry must benefit from a bilateral merger. The identity of the winners – outsiders only (SSR), all firms (PG), or insiders only (IO) – depends on the degree of complementarity between the insiders' R&D stocks, θ . The greater the degree of R&D complementarity that merger allows the insiders to exploit, the more likely it is that a merger will *toughen* competition on the product market (despite its “market power” effects) and, consequently, benefit insiders but harm outsiders. This is our Intuitive Outcome because, in reality, we observe that mergers are both frequently proposed by firms and invariably fiercely opposed by outsiders. Moreover, when the degree of R&D complementarity is sufficiently high, the insiders end up larger (in production volume terms) than the outsiders after a merger. This intuitively-appealing size advantage, which contrasts with the size disadvantage traditionally predicted (e.g. by SSR), occurs because a merger enhances the efficiency of the insiders' R&D stocks in delivering marginal cost reductions and, consequently, encourages the insiders to

invest more in R&D. In the next section we examine the robustness of these findings by assuming instead that firms compete in prices on the product market.

3. Price Competition

To facilitate comparison with the literature, we adopt the same demand curve used by Deneckere and Davidson (1985) in their study of mergers with price competition. Thus, demand is given by

$$(16) \quad q_i = A - p_i + \lambda(\bar{p} - p_i)$$

where $\bar{p} \equiv \frac{1}{N} \sum_j p_j$ denotes the average price charged in the industry. All other assumptions are

identical to those made in our analysis of quantity competition. For notational convenience, we

define the following new terms: $z \equiv \frac{\lambda}{N}$; $\sigma \equiv 1 + \lambda - z$; and $\bar{c} \equiv \frac{1}{N} \sum_j c_j$, so that \bar{c} is the average

marginal cost in the industry.

We begin by analyzing the second stage of competition when the firms remain independent. With the marginal costs already determined, firm i 's profit from sales with R&D expenditures held fixed is given by

$$(17) \quad \pi_i = (p_i - c_i)[A - p_i + \lambda(\bar{p} - p_i)]$$

The firm's first-order condition is then

$$(18) \quad A + \sigma c_i - (1 + \lambda + \sigma)p_i + \lambda\bar{p} = 0$$

Summing (18) over i allows us to solve for the average price in the industry in the Bertrand equilibrium. We obtain

$$(19) \quad \bar{p} = \frac{A + \sigma \bar{c}}{1 + \sigma}$$

We can now use (18) and (19) to solve for firm i 's equilibrium price; however, for later use, it is more convenient to report the equilibrium difference between price and marginal cost. We obtain

$$(20) \quad p_i - c_i = \frac{(1 + \lambda + \sigma)A - (1 + \lambda)(1 + \sigma)c_i + \lambda \sigma \bar{c}}{(1 + \sigma)(1 + \lambda + \sigma)}.$$

Turn next to the R&D stage of competition when the firms are all independent. We begin by noting that the (18), the firm's first-order condition in the price stage, can be written as $q_i = \sigma(p_i - c_i)$. It follows that we can write firm i 's total profits as

$$(21) \quad \pi_i = \sigma(p_i - c_i)^2 - .5\gamma x_i^2$$

where $c_i = c - x_i$. Differentiating (21) with respect to x_i yields the following first-order condition

$$(22) \quad 2\sigma(p_i - c_i) \frac{\partial(p_i - c_i)}{\partial c_i} \frac{\partial c_i}{\partial x_i} = \gamma x_i$$

We can now make use of (20), apply symmetry and solve to obtain the equilibrium level of R&D expenditure for each firm. We obtain

$$(23) \quad x_i = \frac{2\sigma(1 + \lambda + \sigma^2)(A - c)}{\gamma(1 + \sigma)^2(1 + \sigma + \lambda) - 2\sigma(1 + \lambda + \sigma^2)}.$$

Equilibrium profits can then be obtained by substituting (20) and (23) into (21).

We now turn to the case in which firms 1 and 2 merge before R&D expenditures are chosen. Since the qualitative nature of the outsiders' pricing decision remains the same, their first-order condition is still given by (18). However, the insiders now make their second-stage pricing decisions with joint profits in mind. Thus, their first-order conditions become

$$(24) \quad A + c_1(1 + \lambda) + \lambda \bar{p} - 2p_1(1 + \lambda) + z(p_1 - c_1) + z(p_2 - c_2) = 0$$

$$(25) \quad A + c_2(1 + \lambda) + \lambda \bar{p} - 2p_2(1 + \lambda) + z(p_1 - c_1) + z(p_2 - c_2) = 0$$

Summing the first-order conditions for all of the firms allows us to solve for the average industry price in the post-merger price game. We obtain

$$(26) \quad \bar{p} = \frac{(\sigma + \frac{z}{N})A + \sigma^2 \bar{c} - .5(c_1 + c_2) \frac{z}{N}(1 + \lambda)}{\sigma(1 + \sigma) - z^2}.$$

Substitution of (26) into (18) and (24)-(25) then yields the equilibrium prices for the outsiders and the insiders in the post-merger price game

$$(27) \quad p_1 + p_2 = \frac{(1 + \lambda + \sigma)A + \lambda \sigma \bar{c} + .5(c_1 + c_2)[(1 + \sigma)(\sigma - z) - 2z^2]}{\sigma(1 + \sigma) - z^2}$$

$$(28) \quad p_j = \frac{\sigma(1 + \lambda + \sigma)A + \lambda \sigma^2 \bar{c} + \sigma[\sigma(1 + \sigma) - z^2]c_j - .5(c_1 + c_2)(1 + \lambda)z^2}{(1 + \lambda + \sigma)[\sigma(1 + \sigma) - z^2]} \quad \text{for } j \neq 1, 2$$

Finally, we turn to the post-merger R&D competition. For the outsiders, the first-order condition is still given by (22), although we now must use (28) for the equilibrium price (as opposed to eq. 20). For the insiders, it is straightforward to show that their first-order conditions from the price stage imply that $q_1 = \sigma(p_1 - c_1) - z(p_2 - c_2)$ and $q_2 = \sigma(p_2 - c_2) - z(p_1 - c_1)$.

This implies that the merged firm's profits can be written as

$$(29) \quad \pi_1 + \pi_2 = \sigma[(p_1 - c_1)^2 + (p_2 - c_2)^2] - 2z(p_1 - c_1)(p_2 - c_2) - .5\gamma(x_1^2 + x_2^2)$$

with $c_1 = c - x_1 - \theta x_2$ and $c_2 = c - x_2 - \theta x_1$. Differentiating (29) with respect to x_1 yields the following first-order condition

$$(30) \quad 2[\sigma(p_1 - c_1) - z(p_2 - c_2)] \frac{\partial(p_1 - c_1)}{\partial x_1} + 2[\sigma(p_2 - c_2) - z(p_1 - c_1)] \frac{\partial(p_2 - c_2)}{\partial x_1} = \gamma x_1$$

Imposing symmetry, this reduces to

$$(31) \quad 2(p_1 - c_1)(\sigma - z) \frac{\partial[(p_1 + p_2) - (c_1 + c_2)]}{\partial(c_1 + c_2)} \frac{\partial(c_1 + c_2)}{\partial x_1} = \lambda x_1$$

If we use x_m to denote R&D expenditures by a typical insider and use x_o to denote the R&D expenditures for a typical outsider, then we can use (27), (28), the definitions of c_j , c_1 and c_2 , and symmetry to rewrite the first-order conditions in (22) and (31) in a more useful fashion. We obtain

$$(32) \quad \sigma(1 + \lambda + \sigma)(A - c) - z(1 + \theta)[2\sigma^2 - z(1 + \lambda)]x_m = \delta_o x_o$$

$$(33) \quad (1 + \lambda + \sigma)(A - c) - z\sigma(N - 2)x_o = \delta_m x_m$$

where $\psi \equiv \frac{\gamma}{2\sigma} \frac{(1 + \lambda + \sigma)^2 [\sigma(1 + \sigma) - z^2]^2}{(1 + \lambda)[\sigma(1 + \sigma) - z^2] - z\sigma^2}$; $\delta_o \equiv \psi + \{z\sigma^2(N - 2) - (1 + \lambda)[\sigma(1 + \sigma) - z^2]\}$; and

$$\delta_m \equiv \frac{2\gamma[\sigma(1 + \sigma) - z^2]^2}{(\sigma - z)(1 + \theta)[\sigma(1 + \sigma) + z(1 - \sigma)]} - (1 + \theta)[\sigma(1 + \sigma) + z(1 - \sigma)].$$

Equations (32) and (33) can be solved for the equilibrium values of x_m and x_o , which can then be used with (27), (28) and the definitions of costs to calculate the profits of the outsiders (as given in eq. 21) and the merged firm (as given in eq. 29).

Our results for the price game are summarized in Figure 3, which is divided into two regions. Figure 3 has one less region than Figure 1 because with price competition, the insiders always benefit from the merger. Consequently, there is no $\theta_M(\lambda)$ curve in Figure 3. As with Figure 1, the $\theta_o(\lambda)$ curve shows combinations of λ and θ for which the *outsiders* earn the same profits with and without the merger. For higher values of θ , the outsiders are harmed by the merger. It follows that, as with quantity competition, in the PG region all firms gain from the merger while in the IO region the insiders gain from the merger while the outsiders are harmed. The most surprising result from Figure 3 is that the PG region is quite small, so that for almost

all parameter values we get the intuitive outcome. And, although Figure 3 is drawn for the case in which there are 10 firms in the industry, this feature remains even when there are only 3 firms in the industry. Thus, with only weak R&D spillovers a model in which firms compete in process-oriented R&D followed by Bertrand competition yields predictions about horizontal mergers that accord well with our basic intuition.

The forces that generate our results can be explained with the aid of Figure 4, which shows the price charged by a typical insider (P_m^*) and a typical outsider (P_o^*) in the second stage of the game. Of course, since prices are strategic complements, these values vary directly with each other. The solid black lines represent these profit-maximizing values in the absence of the merger, so that the no-merger Nash equilibrium is represented by their intersection.

We begin by focusing on the insiders' price decision in the second stage of competition, holding brand R&D levels fixed at the no-merger equilibrium level. When the insiders merge, it is in their collective interest to increase their prices toward the collusive level. Thus, the merger leads the insiders to charge higher prices than they would in the absence of the merger. This change in behavior is reflected by the upward shift of the P_m^* curve to the dashed red line in Figure 2. Since best-reply functions are upward sloping under price-competition, this shift results in higher prices for the outsiders as well. As a result, the merger causes all firms to increase their prices, with the insiders' prices increasing by a greater amount than the outsiders (for stability). All firms benefit from the merger, but the outsiders benefit by a greater amount. This is the *market power effect* of a horizontal merger that drives the results in Deneckere and Davidson (1985) – the merger causes the insiders to charge higher prices and this benefits both the insiders and the outsiders.

In addition to the market power effect, there is another force at work that alters the outcome in the second stage. Since the merger generates R&D spillovers for the insiders, if we hold the firms' R&D investments at their no-merger levels, then the merger lowers the marginal costs for the insiders. This shifts down their best reply functions toward the blue dashed line in Figure 2. As with Cournot competition, we refer to this change in behavior due to R&D pooling by the insiders as the *R&D pooling effect*.

Now, turn to the first stage of competition. The qualitative impact of the merger on R&D spending is the same as it is under quantity competition. On the one hand, there is a *synergy effect*: because the merger creates spillovers in R&D for the insiders, there is an incentive for the insiders to spend more on R&D following the merger than they would in its absence. On the other hand, the impact of merger on the size of the output base over which insiders' process innovations will be spread is, as with quantity competition, ambiguous. As with quantity competition, when merger-induced spillovers are very weak, the synergy effect is dominated by the contraction in insiders' outputs, and the merger leads to a reduction in R&D spending by the insiders. However, only modest merger-induced spillovers are required for merger to raise the marginal return to R&D for insiders, implying that for most values of θ , the merger leads the insiders to spend more on R&D than they would otherwise.²⁰ This leads to lower marginal costs for all insiders and shifts down their best reply functions for the second stage of competition.²¹ As a result, their prices fall, as reflected by the shift down to the dashed blue line in Figure 4. This is the same *R&D investment effect* that we encountered under quantity competition. As before, the R&D investment effect simply reinforces the shift in the

²⁰ As under Cournot competition, increases in θ strengthen the synergy effect of merger on R&D investment and increase (for any given level of R&D) an insider's output level.

²¹ As noted in footnote 19, even if the insiders respond to the merger by reducing R&D expenditures, their marginal costs are still likely to be reduced by the merger-induced R&D spillovers.

best reply function caused by the R&D pooling effect. As a result, we have an overall R&D effect which causes the insiders to become more aggressive in the second stage of competition. If the overall R&D effect were the only impact of the merger, all firms would end up charging lower prices, the insiders would gain (from the reduction in costs) while the outsiders would lose. It follows that the overall R&D effect works in the opposite direction to the market power effect – it causes the insiders’ prices to fall. This benefits the insiders while harming the outsiders.

As Figure 3 clearly indicates, it takes only weak merger-induced R&D spillovers for the overall R&D effect to dominate the market power effect so that for almost all parameter values we obtain the Intuitive Outcome. As with quantity competition, the level of spillovers required for this increases in λ , since the market power effect is stronger when the goods are more substitutable.

In multidimensional competition where product market interaction is Bertrand, we have shown that inside firms always benefit from a bilateral merger. Whether outsiders gain (PG) or lose (IO) depends on the degree of complementarity between the insiders’ R&D stocks, θ . For a non-trivial degree of R&D complementarity, we generate intuitively-appealing results under Bertrand competition: (a) insiders gain from merger; (b) outsiders lose; and (c) insiders end up larger than outsiders in production volume terms. The toughening of product market competition caused by the merger-induced exploitation of R&D complementarities accounts for (a) and (b), and it contributes – together with the “synergy” effect of merger – to (c). Moreover, a comparison of our Cournot and Bertrand results shows that, for a sufficiently large degree of R&D complementarity, we obtain this Intuitive Outcome *independently of the strategic variable in market competition*. This feature represents a significant advance on the findings of existing

models of merger to achieve market power alone, which are well known to be highly sensitive to the assumed mode of product market competition. In contrast, the strategic variable in market competition, an unobservable characteristic of real-world product markets, plays no role in this important qualitative result.

4. Conclusion

The motivation for our analysis was the empirical proposition that horizontal mergers often appear to be motivated by a desire to exploit complementarities between the insiders' R&D stocks. The merger in 2000 between BP and ARCO, which was justified on the grounds that the resulting pooling of technical knowledge would significantly reduce oil extraction costs, provides a solid example of this mechanism. We studied the equilibrium outcomes of multidimensional competition, where firms compete in process R&D and then on the product market, and the positive effects of a prior bilateral merger. Our modeling structure incorporated two distinct motives for merger: first, a traditional "market power" (or "strategic") motive; and second, a novel "R&D pooling" motive to reflect the empirical driver of mergers noted above: a merged firm can apply the process R&D conducted on one inside brand to the production of the merger-partner's brand, thereby exploiting the "public good" nature of R&D output to generate extra process innovations from given R&D stocks. The game was solved backwards, generating predictions for the effects of merger on both process R&D investments and product market actions. In particular, because R&D investments are endogenously determined and merger allows R&D complementarities to be exploited, our model can be interpreted as providing an account of the size of the "synergy" benefits of merger.

Our most significant results occur whenever the degree of R&D complementarity (or “technical closeness”) between brands is non-trivial. In this case, relative to the (symmetric) no-merger equilibrium, a bilateral merger has the following positive properties: (a) insiders (i.e. merger participants) benefit; (b) outsiders (i.e. non-participants) are harmed; and (c) insiders end up larger than outsiders. We describe the conjunction of these three features as the “Intuitive Outcome” because it accords with our basic intuition on the effects of merger. The mechanism behind these results is that a non-trivial degree of R&D complementarity simultaneously encourages extra process R&D investment by the insiders and, by toughening competition on the product market, discourages R&D spending by the outsiders. Importantly, we obtain these intuitively-appealing results *independently of the strategic variable in market competition* (price vs. quantity). This represents a significant advance on the findings of existing models of merger to achieve market power alone, which are well known to be both extremely counterintuitive and highly sensitive to the assumed mode of product market competition. In contrast, the strategic variable in market competition, an unobservable characteristic of real-world product markets, plays no role in our central qualitative results.

An assumption of our analysis is that merger represents the only means of exploiting R&D complementarities. In particular, we ruled out (inter-firm) contractual methods, such as RJVs. In many cases, this is an appropriate assumption: contracts are often extremely costly both to write and to enforce, and cataloguing desired actions in all appropriate states of the world is a formidably complex task. In this connexion, it is interesting to note that BP and ARCO had tried, before finally merging in 2000, to exploit the complementarities between their stocks of technical expertise via contractual means for over twenty years without success (Farrell and Shapiro, 2001, p. 705). However, an interesting extension of our analysis

(especially in the case of Bertrand competition on the product market) would be to allow for RJVs alongside merger and to compare the profitabilities of those two alternative vehicles for exploiting R&D complementarities.

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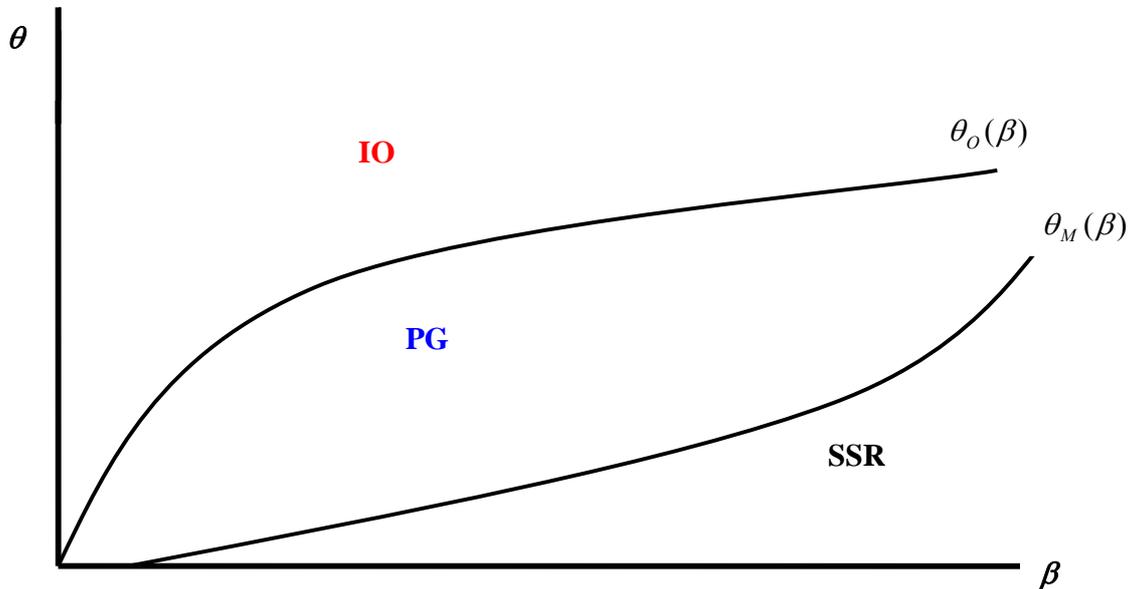


Figure 1
Outcomes with Quantity Competition

Notes: For $\theta = \theta_o$, the outsiders earn the same profits with and without the merger. For $\theta = \theta_M$, the insiders earn the same profits with and without the merger. In the SSR region we have the Salant, Switzer and Reynolds outcome; in the PG region all firms gain from the merger (so there is a Pareto Gain); and, in the IO outcome we have the Intuitive Outcome (the insiders gain from the merger while the outsiders lose). The curves in Figure 1 correspond to the case in which $N = 10$, $\gamma = 2$, $A = 3$, and $c = 2$.

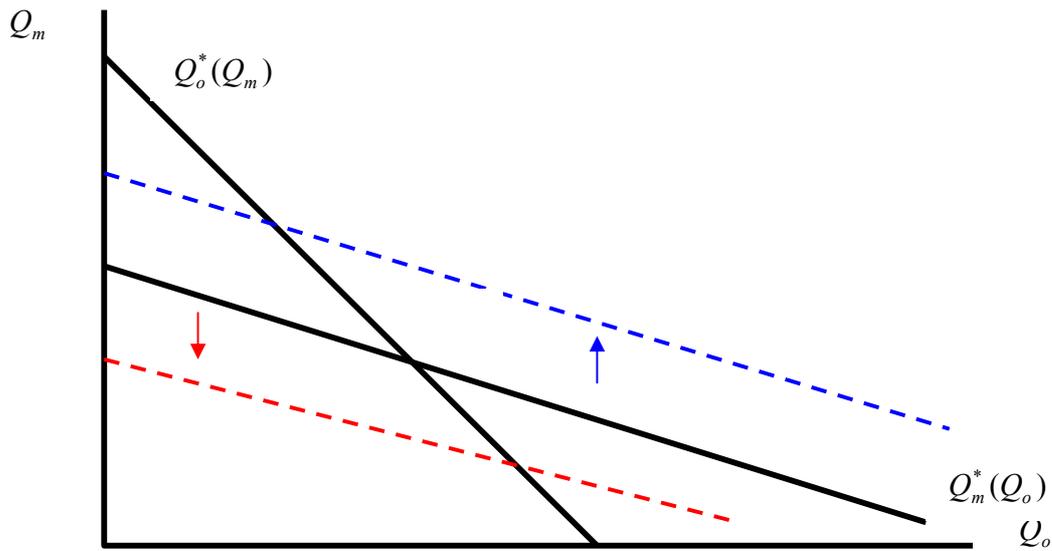


Figure 2
The Impact of the Merger with Quantity Competition

Notes: The solid black lines show how aggregate output by the insiders and the outsiders vary with each other in the no-merger case. Their intersection determines the no-merger Nash outcome. The shift down to the dashed red line is due to the “market power” effect of the merger. The shift up to the dashed blue line is due to the “R&D pooling” effect of the merger.

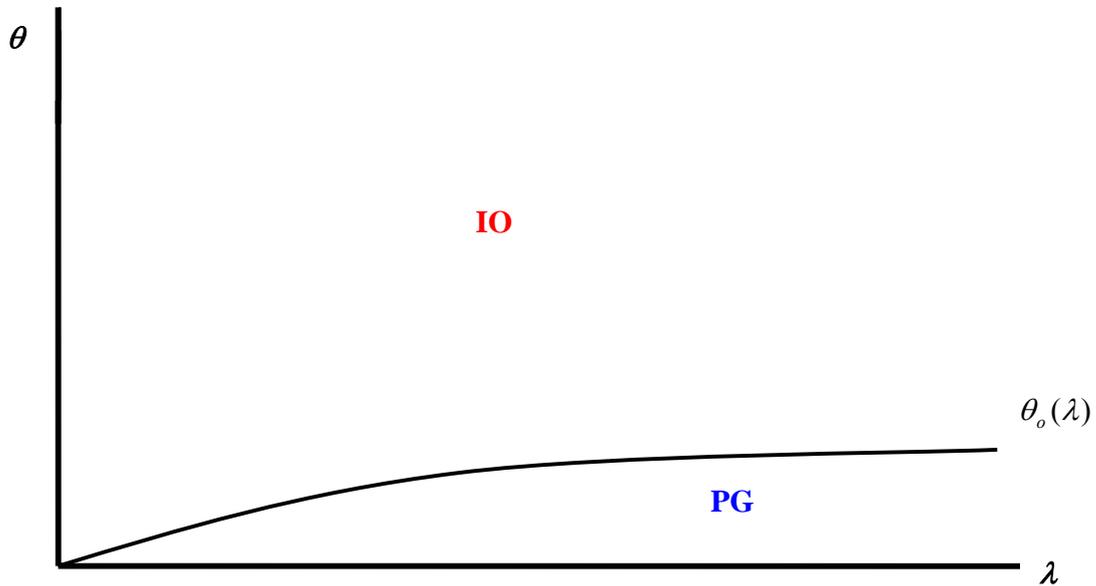


Figure 3
Outcomes with Price Competition

Notes: For $\theta = \theta_o$, the outsiders earn the same profits with and without the merger. In the PG region all firms gain from the merger (so there is a Pareto Gain); and, in the IO outcome we have the Intuitive Outcome (the insiders gain from the merger while the outsiders lose). The curves in Figure 3 correspond to the case in which $N = 10$, $\gamma = 2$, $A = 3$, and $c = 2$.

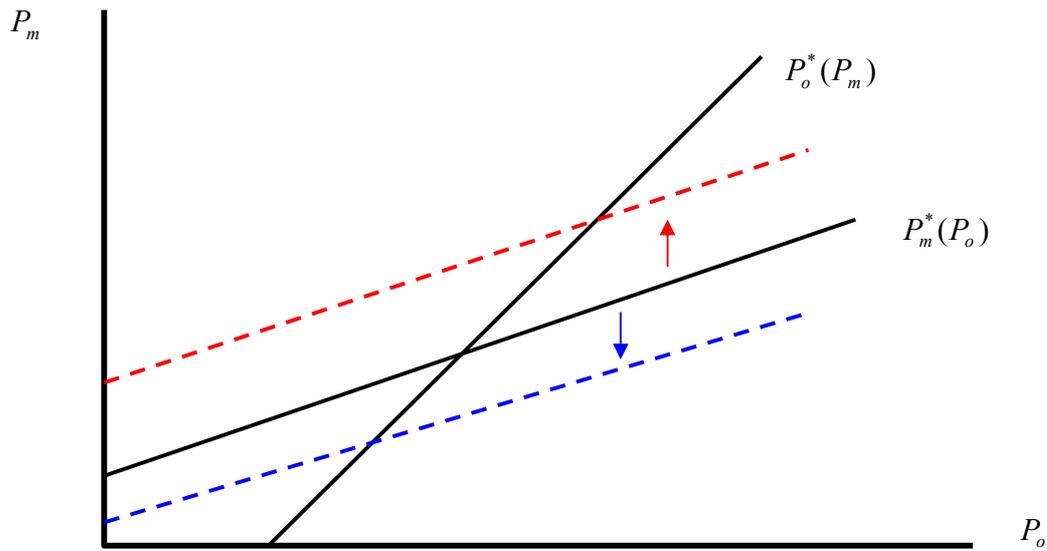


Figure 4
The Impact of the Merger with Price Competition

Notes: The solid black lines show how the price of a typical insider and a typical outsider varies with each other in the no-merger case. Their intersection determines the no-merger Nash outcome. The shift up to the dashed red line is due to the “market power” effect of the merger. The shift down to the dashed blue line is due to the “R&D pooling” effect of the merger.