Horizontal Merger Policy: New Work on an Old Problem*

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1 Introduction

Mergers play an important allocative role in the global economy. By exploiting potential synergies between tangible and intangible assets of the merging firms, they may improve the efficiency of production. At the same time, mergers may create or enhance market power at the expense of consumers and society. This concern is particularly important for horizontal mergers – combinations of firms competing in the same market. Horizontal merger control is therefore one of the central pillars of antitrust policy.

In this chapter, I provide a survey of recent advances in the academic literature on horizontal merger policy. Throughout, I focus on mergers' *unilateral effects*, ignoring potential *coordinated effects*. That is, I abstract from the impact that mergers may have when attempting to collude. This focus reflects antitrust practice in the last two decades or more: nowadays, most merger investigations revolve around unilateral effects, perhaps also because coordinated effects are much less-well understood. This survey provides a very idiosyncratic reading of the recent literature in that I focus almost exclusively on my own work on the topic, developed in collaboration with my co-authors Michael Whinston, Nicolas Schutz, and others.

In Section 2, I begin by reviewing the seminal contributions on the static ("Williamson") trade-off between the market power and efficiency effects of horizontal mergers: Williamson (1968) and Farrell and Shapiro (1990). I then turn to recent advances in the analysis of this trade-off: mergers in multiproduct-firm oligopoly (Nocke and Schutz, 2019), concentration

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screens for horizontal mergers (Nocke and Whinston, 2020), and mergers in open economies (Breinlich et al., 2020).

In Section 3, I survey recent contributions that derive the optimal merger approval policy in environments with endogenous merger proposals: merger policy in a dynamic model with endogenous but disjoint mergers (Nocke and Whinston, 2010), merger policy in a static model in which firms can choose which merger to propose (Nocke and Whinston, 2013), and merger policy in a dynamic model with endogenous investment (Mermelstein et al., 2020).

In Section 4, I conclude by briefly discussing a few promising avenues for future research.

2 The Williamson Trade-off

At the heart of any unilateral effects analysis of mergers is the trade-off between the *market power effect* and the possible *efficiency effect*. The former arises from the internalization of competitive externalities post merger, while the latter may arise from merger-induced synergies in procurement, production or distribution. This trade-off was first identified by Williamson (1968) in a diagrammatic analysis of a merger of a perfectly competitive industry to monopoly.

2.1 Merger of a perfectly competitive industry to monopoly

Consider an industry with market demand $Q(\cdot)$ and inverse demand $P(\cdot)$, satisfying the standard assumptions, notably $P'(Q) < 0$ and $P'(Q) + QP''(Q) < 0$ for all Q such that $P(Q) > 0$, and $\lim_{Q\to\infty} P(Q) = 0$. Suppose that there are n identical firms, each with constant marginal cost c, that behave as price takers. The equilibrium price is thus $p^* = c$ and the equilibrium industry-level output $Q^* = Q(c)$. Suppose now that these n firms merge to monopoly and that the post-merger marginal cost is $\overline{c}$. The resulting post-merger quantity, $\overline{Q}^*$, satisfies the first-order condition $P(\overline{Q}^*) - \overline{c} + \overline{Q}^* P'(\overline{Q}^*) = 0$.

While Williamson (1968) focuses on the merger's impact on aggregate surplus, it is instructive to consider first the impact on consumer surplus. (In most jurisdictions, antitrust authorities have adopted something close to a consumer surplus standard.[1]) From the first-order condition of profit maximization, the merger is *CS-nondecreasing* (i.e., it either raises consumer surplus or leaves it unchanged) if

$$\underbrace{c - \overline{c}}_{\text{efficiency effect}} \geq \underbrace{-Q(c)P'(Q(c))}_{\text{market power effect}}; \tag{1}$$

it is *CS-decreasing* if the l.h.s. is strictly smaller than the r.h.s.; and it is *CS-neutral* if the equation holds with equality. The l.h.s. of equation (1) represents the merger's efficiency

[1]The perceived wisdom on merger authorities' objective function is summarized by Whinston (2007) as follows: "[...] enforcement practice in most countries (including the U.S. and the E.U.) is closest to a consumer surplus standard."

effect—the change in profit from the marginal unit of output. The r.h.s. represents the market power effect—the reduction in infra-marginal revenue from raising output slightly above its pre-merger level. Re-writing equation (1), we can see that the merger is CS-nondecreasing if and only if the post-merger marginal cost $\overline{c}$ is below some cutoff $\hat{c}$, defined as

$$\hat{c} \equiv c + Q(c)P'(Q(c)) < c. \tag{2}$$

The sign of the aggregate surplus effect can be derived in a similar fashion. The merger is *AS-nondecreasing* (i.e., does not decrease aggregate surplus) if and only if

$$c - \overline{c} \geq \frac{\int_{\overline{Q}^*}^{Q^*} [P(Q) - c] dQ}{\overline{Q}^*}. \tag{3}$$

It is straightforward to show that there exists a unique cutoff such that the merger is AS-nondecreasing if and only if the post-merger marginal cost is below that cutoff.

The Williamson (1968) analysis focuses on a setting that is very special, in at least three dimensions. First, it considers a merger to monopoly. However, if there are non-merging outsiders (as there almost always are in practice), then the overall welfare impact of the merger will crucially depend on how these outsiders respond to the merger partners' changed incentive to produce output. Second, Williamson (1968) assumes that the market is perfectly competitive prior to the merger. This implies that the integrand on the r.h.s. of condition (3) is no longer zero, but strictly positive, when evaluated at the pre-merger equilibrium output level. Hence, reducing aggregate output below its pre-merger level has only a second-order effect on the r.h.s. of equation (3)—whereas it would have a first-order effect if the pre-merger profit margin were positive. Third, Williamson (1968) assumes that all firms produce at the same marginal cost prior to the merger. However, if firms have heterogeneous marginal costs, then the merger has the potential to increase productive efficiency by shifting output across its partners. In their seminal paper, Farrell and Shapiro (1990) address these issues by analyzing the Williamson trade-off in the homogeneous-goods Cournot model.

2.2 Mergers in the homogeneous-goods Cournot model

Consider a homogeneous-goods industry in which a set $\mathcal{F}$ of firms compete in a Cournot fashion. Using a constant returns-to-scale technology, let c_f and q_f denote the marginal cost and output of firm $f \in \mathcal{F}$, respectively.[2] Inverse demand is given by $P(Q)$, where $Q = \sum_{f \in \mathcal{F}} q_f$ is aggregate output, and assumed to satisfy the standard assumptions made above. Given a profile of output choices $(q_g)_{g \in \mathcal{F}}$, firm f's profit is given by $\pi_f = [P(Q) - c_f]q_f$. Note that this expression depends on the output choices of rivals only through the "aggregator" Q; the homogeneous-goods Cournot model is thus an *aggregative game*.

[2] While Farrell and Shapiro (1990) allow for non-constant marginal costs, for expositional simplicity, I will focus here on the case of constant returns to scale.

Before analyzing mergers, it is useful to review the aggregative games approach to studying equilibrium in the Cournot model.[3] This approach requires that first-order conditions are sufficient for individual optimality, which they are in the Cournot model under the standard assumptions on demand (made in Section 2 above). The aggregative games approach proceeds in two steps. First, for any given level of aggregate output, derive each firm's profit-maximizing output. Second, find the level of aggregate output that is consistent with firms' individual output choices.

Fix aggregate output Q, and consider firm f. If $P(Q) \leq c_f$, firm f's optimal output level is zero; if instead $P(Q) > c_f$, it is uniquely determined by the familiar first-order condition

$$P(Q) - c_f + q_f P'(Q) = 0.$$

The firm's profit-maximizing quantity can thus be written as

$$q_f = r(Q; c_f) \equiv \max\left(\frac{P(Q) - c_f}{-P'(Q)}, 0\right).$$

The *fitting-in function* $r(Q; c)$ gives the optimal output level of a firm with marginal cost c when aggregate output is Q. If $r(Q; c) > 0$, the fitting-in function is locally strictly decreasing in both Q and c: the larger is aggregate output or the higher is its marginal cost, the less does a firm optimally produce.

In equilibrium, the sum of firms' individual output levels must be equal to aggregate output:

$$R(Q) \equiv \sum_{f \in \mathcal{F}} r(Q; c_f) - Q = 0.$$

As $R(Q)$ is strictly decreasing in Q, $R(0) \geq 0$ (with a strict inequality if $P(0) > \min_{f \in \mathcal{F}} c_f$), and $R(Q) < 0$ for Q sufficiently large, there exists a unique Q^* such that $R(Q^*) = 0$. That is, there exists a unique equilibrium in the Cournot model: aggregate output is Q^* and firm f's output is $q_f^* = r(Q^*; c_f)$.

Comparative statics are well behaved. Consider an increase in firm f's marginal cost c_f, assuming that the firm is initially active in that $q_f^* = r(Q^*; c_f) > 0$. As this change in c_f does not affect the fitting-in function of any firm other than f, and decreases $r(Q; c_f)$ for any Q at which $r(Q; c_f) > 0$, it immediately follows that equilibrium aggregate output Q^* decreases. Moreover, since $r(Q; c_g)$ is decreasing in Q, this in turn implies that the equilibrium output and profit of any firm $g \neq f$, $q_g^* = r(Q^*; c_g)$ and $\pi_g^* = [P(Q^*) - c_g]r(Q^*; c_g)$ increases (and strictly so if firm g was initially active). By contrast, the equilibrium profit of firm f, π_f^*, decreases due to the increase in own marginal cost c_f and the induced increase of rivals' outputs.

Consider now a merger M between the firms in set $M \subset \mathcal{F}$, and let $\overline{c}_M$ denote the post-merger marginal cost. For expositional simplicity, suppose that all merger partners are active

[3] In the context of the Cournot model, this approach was pioneered by Selten (1970) and McManus (1962, 1964) and applied by Szidarovszky and Yakowitz (1977) and Novshek (1985).

before the merger: $r(Q^*, c_f) > 0$ for all $f \in M$, where Q^* denote the equilibrium aggregate output prior to the merger.

As the merger does not affect the fitting-in functions of the non-merging outsiders, it is CS-neutral if and only if

$$r(Q^*; \overline{c}_M) = \sum_{f \in M} r(Q^*; c_f)$$

or, equivalently,

$$P(Q^*) - \overline{c}_M = \sum_{f \in M} \left[P(Q^*) - c_f\right]. \tag{4}$$

Rewriting, the merger is CS-neutral if and only if

$$\overline{c}_M = P(Q^*) - \sum_{f \in M} \left[P(Q^*) - c_f\right] \equiv \hat{c}_M. \tag{5}$$

Since equilibrium aggregate output (and thus consumer surplus) is strictly decreasing in the post-merger marginal cost $\overline{c}_M$, the merger is CS-decreasing if $\overline{c}_M > \hat{c}_M$ and CS-increasing if $\overline{c}_M < \hat{c}_M$. A key insight of Farrell and Shapiro (1990) is that a merger among active firms has to involve (sufficiently large) synergies for it to be CS-nondecreasing: equation (5) implies that $\hat{c}_M < \min_{f \in M} c_f$.

By contrast, aggregate surplus does not necessarily increase with the merger-induced efficiencies.[4] Farrell and Shapiro (1990) therefore focus on the merger's *external effect*, defined as the induced change in the sum of consumer surplus and the non-merging outsiders' joint profit. To the extent that a merger is proposed only if it is in the merger partners' interest, a positive external effect would thus be a sufficient condition for the merger to increase aggregate surplus.

Formally, let $\mathcal{O} \equiv \mathcal{F} \setminus M$ denote the set of non-merging outsiders, and

$$W(Q) \equiv \int_0^Q [P(z) - P(Q)]dz + \sum_{f \in \mathcal{O}} [P(Q) - c_f] r(Q; c_f)$$

the sum of consumer surplus and the profit of the non-merging outsiders when (equilibrium) aggregate output is Q. The external effect of merger M is thus given by $W(\overline{Q}^*) - W(Q^*)$. A useful "trick" used by Farrell and Shapiro (1990) consists in re-writing the external effect as

$$W(\overline{Q}^*) - W(Q^*) = \int_{Q^*}^{\overline{Q}^*} W'(Q)dQ,$$

where $W'(Q)dQ$ can be thought of as the external effect of an "infinitesimal" merger that

[4] In fact, if the merged firm is sufficiently inefficient, so that $P(Q^*) - \overline{c}_M$ is sufficiently close to zero, a small reduction in the post-merger marginal cost $\overline{c}_M$ necessarily decreases aggregate surplus by shifting output from more efficient outsiders to the merged firm; see Lahiri and Ono (1988) and Zhao (2001).

changes equilibrium aggregate output by dQ. Differentiating $W(Q)$, yields:

$$W'(Q) = -QP'(Q) + P'(Q)\sum_{f\in\mathcal{O}} r(Q;c_f) + \sum_{f\in\mathcal{O}}[P(Q)-c_f]\frac{\partial r(Q;c_f)}{\partial Q}. \tag{6}$$

Let $s_f(Q) \equiv r(Q;c_f)/Q$ denote the market share of firm f and $\sigma(Q) \equiv -QP''/P'(Q) < 1$ the curvature of inverse demand. As

$$\frac{\partial r(Q;c_f)}{\partial Q} = -1 + \sigma(Q)s_f(Q), \tag{7}$$

equation (6) can be rewritten as

$$W'(Q) = -QP'(Q)\left\{1 - \sum_{f\in\mathcal{O}} s_f(Q) - \sum_{f\in\mathcal{O}} s_f(Q)\left[1-\sigma(Q)s_f(Q)\right]\right\}.$$

Hence, evaluated at Q, an infinitesimal CS-decreasing (i.e., output-decreasing) merger has a non-negative external effect if and only if

$$1 - \sum_{f\in\mathcal{O}} s_f(Q) \leq \frac{1}{2}\left[1 - \sigma(Q)\sum_{f\in\mathcal{O}} s_f^2(Q)\right]. \tag{8}$$

It is straightforward to verify that this condition is "more likely" to hold if any outsider $f \in \mathcal{O}$ commands a larger market share $s_f(Q)$.[5] The intuition is simple. While the decrease in aggregate output decreases consumer surplus, there are two countervailing effects on the profits of non-merging outsiders, both of which depend on market structure. First, the induced increase in price raises the outsiders' profits—and the size of this effect is proportional to outsiders' market shares.[6] Second, the outsiders optimally respond by increasing their outputs; the corresponding increase in outsiders' profits is also proportional to their market shares if demand curvature is zero.[7] The magnitude of this output response, however, is heterogeneous across outsiders in case of non-zero demand curvature: as can be seen from equation (7), it is larger for larger firms if $\sigma(Q) < 0$, and larger for smaller firms if $\sigma(Q) > 0$. Since larger firms command a larger markup, this means that condition (8) is easier to satisfy after a sum-preserving spread (resp., contraction) of the market shares of the outsiders if $\sigma(Q) < 0$ (resp., $\sigma(Q) > 0$).

Consider a CS-decreasing merger that reduces equilibrium aggregate output from Q^* to $\overline{Q}^* < Q^*$. If demand curvature is nondecreasing (i.e., $\sigma'(Q) \geq 0$ for all $Q \in [\overline{Q}^*, Q^*]$), then

[5] To see this, let $\Psi \equiv 1 - \sum_{f\in\mathcal{O}} s_f - \frac{1}{2}\left[1 - \sigma\sum_{f\in\mathcal{O}} s_f^2\right]$. The assertion follows from $\partial\Psi/\partial s_f = -1 + \sigma s_f < 0$.

[6] For an infinitesimal merger, this effect corresponds to the second term on the r.h.s. of equation (6).

[7] For an infinitesimal merger, this effect corresponds to the third term on the r.h.s. of equation (6). Noting that the markup $[P(Q) - c_f]$ is equal to $-r(Q;c_f)P'(Q)$, this third term is equal to the second term if $\sigma(Q) = 0$.

for this merger to have a non-negative external effect, it suffices that condition (8) is satisfied at the pre-merger equilibrium aggregate output level Q^*:[8]

$$s_M(Q^*) \leq \frac{1}{2}\left[1 - \sigma(Q^*) \sum_{f \in \mathcal{O}} \mathrm{HHI}^{\mathcal{O}}(Q^*)\right],$$

where $s_M(Q^*) \equiv \sum_{f \in M} s_f(Q^*)$ is the sum of the pre-merger market shares of the merger partners and $\mathrm{HHI}^{\mathcal{O}}(Q^*) \equiv \sum_{f \in \mathcal{O}} s_f^2(Q^*)$ is the pre-merger Herfindahl index among non-merging outsiders. This is a remarkable result, as the condition requires knowledge only of pre-merger market shares and pre-merger demand curvature. In the special case of linear demand ($\sigma(Q) = 0$), the condition takes a particularly simple form: a CS-decreasing merger has a non-negative external effect if and only if the joint market share of the merger partners does not exceed fifty percent. More generally, the external effect of a CS-decreasing merger is non-negative as long as the sum of the pre-merger market shares of the merger partners is sufficiently small.

2.3 Mergers in multiproduct-firm oligopoly

Most firms offer multiple products. However, because of technical difficulties in dealing with multiproduct-firm oligopoly, the literature has long been lacking an equilibrium model of horizontal mergers in such a setting. Building on the aggregative games approach to multiproduct-firm oligopoly developed in Nocke and Schutz (2018), Nocke and Schutz (2019) provide an extensive analysis of the unilateral effects of horizontal mergers under price competition with (nested) CES and MNL demands.

Let $\mathcal{N}$ denote the set of products. Abstracting from the nested demand structure for expositional simplicity, consumer surplus is given by

$$V(p) = \log H(p),$$

where $p = (p^k)_{k \in \mathcal{N}}$ is the price vector, and

$$H(p) \equiv \sum_{k \in \mathcal{N}} h^k(p^k) + H_0.$$

Here, H_0 represents the value of the outside option, $h^k(p^k) = a^k (p^k)^{1-\sigma}$ in the case of CES demand and $h^k(p^k) = \exp((a^k - p^k)/\lambda)$ in the case of MNL demand, with $a^k > 0$ a measure of product quality, and $\sigma > 1$ and $\lambda > 0$ measures of price sensitivity.

The set of firms, $\mathcal{F}$, is a partition of $\mathcal{N}$. Assuming a constant returns to scale technology,

[8] To see this, let $\Psi(Q) \equiv 1 - \sum_{f \in \mathcal{O}} s_f(Q) - \frac{1}{2}[1 - \sigma(Q) \sum_{f \in \mathcal{O}} s_f^2(Q)]$. Differentiating, yields $\Psi'(Q) = -[1 - \sigma(Q)] \sum_{f \in \mathcal{O}} s'_f(Q) + \frac{1}{2}\sigma'(Q) \sum_{f \in \mathcal{O}} s_f^2(Q) \geq 0$, where the inequality follows from $\sigma(Q) < 1$, $\sigma'(Q) \geq 0$, and $s'_f(Q) \leq 0$.

the profit of firm $f \in \mathcal{F}$ can be written as

$$\pi^f(p) = \sum_{k \in f} (p^k - c^k) \frac{-h^{k\prime}(p^k)}{H(p)}.$$

Note that firm f's profit depends on the prices set by other firms only through the value of the uni-dimensional aggregator $H(p)$. The associated multiproduct-firm pricing game is therefore aggregative. As in Section 2.2, this allows solving for the equilibrium in two steps. First, holding fixed the value of the aggregator H, derive each firm's optimal price vector using first-order conditions. Second, solve for the value of H that is consistent with firms' optimal pricing decisions.

From the first-order conditions of profit maximization,

$$\frac{p^k - c^k}{p^k} \iota^k(p^k) = \frac{p^l - c^l}{p^l} \iota^l(p^l) \equiv \mu_f \quad \forall k, l \in f, \tag{9}$$

where $\iota^k(p^k) \equiv -p^k h^{k\prime\prime}(p^k)/h^{k\prime}(p^k)$ is the price elasticity of demand for product k as perceived under monopolistic competition (where firms would take the value of the aggregator as given). Nocke and Schutz (2018) dub this the *common ι-markup property*: there exists a scalar μ_f such that firm f optimally sets its percentage markup for each product k equal to that scalar, divided by that product's perceived price elasticity ι^k. As $\iota^k(p^k) = \sigma$ under CES demand, and $\iota^k(p^k) = p^k/\lambda$ under MNL demand, this means that firm f optimally sets the same relative markup on all its products under CES demand, and the same absolute markup on all its products under MNL demand. The common ι-markup property implies a reduction in the dimensionality of the problem: it suffices to solve for each firm's optimal ι-markup μ_f, as the firm's prices for the various products can then be backed out from equation (9).

Under CES/MNL demands, an additional aggregation property applies: *type aggregation*. That is, all relevant information about firm f—the vector of firm f's products with its associated qualities and marginal costs—can be summarized in a single-dimensional sufficient statistic, its type T_f. Firm f's type is defined as $T_f \equiv \sum_{k \in f} h^k(c^k)$, and is equal to the firm's contribution to the aggregator (and thus to consumer surplus) if it were to price all its products at marginal cost.

From the demand function, firm f's market share, s_f, measured in value under CES demand and in volume under MNL demand, can be written as

$$s_f = \frac{T_f}{H} \left(1 - \frac{\mu_f}{\sigma}\right)^{\sigma - 1}$$

in the CES case, and

$$s_f = \frac{T^f}{H} e^{-\mu^f}$$

in the MNL case. From the first-order condition, we get another relationship between firm

f's market share and its optimal ι-markup μ_f:

$$\mu_f(1-\alpha s_f)=1,$$

where $\alpha=(\sigma-1)/\sigma$ in the CES case and $\alpha=1$ in the MNL case. In each case, the system of two equations has a unique solution in μ_f and s_f: the *markup fitting-in function* $m(T_f/H)$ and the *market share fitting-in function* $S(T_f/H)$. Both fitting-in functions are strictly increasing: the higher is the firm's type (i.e., the larger is T_f) or the less intense is competition (i.e., the lower is H), the larger is the firm's optimal markup and market share.

The equilibrium value of the aggregator, H^*, is the unique solution in H of the condition

$$\sum_{f\in\mathcal{F}} S\left(\frac{T_f}{H}\right)+\frac{H_0}{H}=1,$$

which simply says that market shares (including the share of the outside option) have to add up to one.

Nocke and Schutz (2019) show that the type aggregation property is very useful for merger analysis: while a merger may affect the merger partners' product portfolio in different ways (through the number of products, product qualities, and marginal costs), all that is required for the analysis is the firm's post-merger type $\overline{T}_M$. Note that in the case of no synergies—in which the merged firm produces exactly the same number of products, with the same qualities and at the same marginal costs, as the merger partners did jointly before the merger—we would have $\overline{T}_M=\sum_{f\in M}T_f$. For the merger to be CS-nondecreasing, however, requires that

$$S\left(\frac{\overline{T}_M}{H^*}\right)\geq\sum_{f\in M}S\left(\frac{T_f}{H^*}\right),$$

or

$$\overline{T}_M\geq S^{-1}\left(\sum_{f\in M}S\left(\frac{T_f}{H^*}\right)\right)\equiv\hat{T}_M,$$

and for it to be CS-neutral requires that these equations hold with equality. From the subadditivity of the market share fitting-in function, it follows that $\hat{T}_M>\sum_{f\in M}T_f$. In short: a CS-nondecreasing merger must induce sufficiently large synergies.

Nocke and Schutz (2019) show that aggregate surplus is strictly increasing in the post-merger type $\overline{T}_M$. Hence, there exists a threshold type $\tilde{T}_M$ such that the merger is AS-nondecreasing if and only if $\overline{T}_M\geq\tilde{T}_M$. (Recall from our discussion above that no analog of this result is available in the homogeneous-goods Cournot model.) Moreover, as a CS-neutral merger is profitable for the merger partners (and does not affect the profit of the non-merging outsiders), $\tilde{T}_M<\hat{T}_M$.

Following Farrell and Shapiro (1990), Nocke and Schutz (2019) also analyze a merger's external effect. They show that the external effect of an infinitesimal merger that changes the value of the aggregator by dH can be written as $-\eta(H)dH/H$, where

$$\eta(H) \equiv -1 + \sum_{f \in \mathcal{O}} \frac{T_f}{H} m' \left(\frac{T_f}{H} \right) = -1 + \sum_{f \in \mathcal{O}} \frac{\alpha s_f (1 - s_f)}{(1 - \alpha s_f)(1 - s_f + \alpha s_f^2)},$$

with $\mathcal{O}$ denoting again the set of non-merging outsiders. The external effect of a CS-decreasing merger is necessarily negative if $\alpha \leq \overline{\alpha} \equiv 3(\sqrt{57} - 7)/2 \approx 0.82$. If, however, $\alpha > \overline{\alpha}$—which always holds under MNL demand and holds under CES demand for σ large—then there exist CS-decreasing mergers with a positive external effect; this effect is "more likely" to be positive when the non-merging outsiders have higher or more concentrated market shares.

Johnson and Rhodes (2020) analyze horizontal mergers in the Johnson and Myatt (2006) Cournot-model with pure vertical product differentiation. There are two quality levels, a low quality and a high quality. Each firm may produce either quality, or both, using a constant-returns-to-scale technology. Denoting the aggregate quantity of both qualities by Q_1 and that of high quality only by $Q_2 \leq Q_1$, the resulting prices for the good's low-quality and high-quality version are given by $P_1(Q_1)$ and $P_1(Q_1) + P_2(Q_2)$, respectively.[9] Each firm's profit therefore depends on the actions of its rivals through *two* aggregators, Q_1 and Q_2. Compared to the homogeneous-goods Cournot model, this additional flexibility implies that some of the conclusions of Farrell and Shapiro (1990) do not hold in their setting.

Most importantly, mergers without synergies may sometimes benefit consumers. To see this, consider a merger between two firms that produce only the low-quality version of the good. Suppose also that there is a non-merging outsider that offers only high quality. Absent synergies, the merged firm has an incentive to restrict the output of low quality. The best response of the non-merging outsider consists in increasing its own high-quality output. It is possible to construct examples in which the latter effect may be so strong that the consumer benefit from the increase in high-quality output outweighs the consumer harm from the decrease in low-quality output.

2.4 Welfare impact and concentration measures

Concentration measures play an important role in merger control, both at the screening stage (at which antitrust authorities have to decide whether to investigate further a proposed merger) as well as in court proceedings. In the United States, the *Horizontal Merger Guidelines* state safe harbor presumptions as well as presumption of anticompetitive effects based on the (post-merger) Herfindahl index and the merger-induced change in that index, both naively computed (i.e., assuming that the market shares of the non-merging outsiders do not change). Nocke and Whinston (2020) argue that the basis for these presumptions, both in form and level, is unclear.

[9] That is, $P_1(\cdot)$ is the inverse demand function for the low-quality version and $P_2(\cdot)$ the inverse demand function for the "upgrade" to high quality.

One possible approach to shed light on this issue involves relating the possible welfare impact of a merger to concentration measures. This is the route taken in Nocke and Schutz (2019), for the benchmark case in which the merger does not induce any synergies. Considering price competition with (nested) CES and MNL demands with an outside option $H_0 > 0$, they provide a second-order approximation of the consumer surplus and aggregate surplus effects of a merger, with the approximation being taken around small market shares.[10]

The approximation proceeds in several steps. First, fix a pre-merger vector of market shares, $s = (s_f)_{f \in \mathcal{F}}$, assuming the market share of the outside good is strictly positive. Second, use this vector to recover the pre-merger type vector and the pre-merger values of consumer surplus, $\text{CS}(s) = \log H_0 + \log(1 - \sum_{f \in \mathcal{F}} s_f)$, and aggregate surplus, $\text{AS}(s) = \text{CS}(s) + \sum_{f \in \mathcal{F}} \alpha s_f / (1 - \alpha s_f)$, where $\alpha = (\sigma - 1)/\sigma$ for CES demand and $\alpha = 1$ for MNL demand. Third, use the post-merger type vector, assuming no merger-induced synergies, to obtain the post-merger vector of marginal costs, $\overline{s}(s) = (\overline{s}_f(s))_{f \in \mathcal{F}}$ and the post-merger values of the welfare measures, $\text{CS}(\overline{s}(s))$ and $\text{AS}(\overline{s}(s))$. Finally, apply Taylor's theorem to obtain:

$$\text{CS}(\overline{s}(s)) - \text{CS}(s) = -\alpha \Delta \, \text{HHI}(s) + o(||s||^2)$$

and

$$\text{AS}(\overline{s}(s)) - \text{AS}(s) = -\alpha \Delta \, \text{HHI}(s) + o(||s||^2),$$

where $\Delta \, \text{HHI}(s)$ is the naively-computed change in the Herfindahl index. That is, both the consumer surplus and aggregate surplus loss induced by a merger without synergies is approximately proportional to the merger-induced change in the naively-computed index.

An alternative approach involves relating the synergy level required to make the merger CS-neutral to concentration measures. This is the route taken, both theoretically and empirically, in Nocke and Whinston (2020). In the theoretical part of their paper, Nocke and Whinston derive the required synergy level in the homogeneous-goods Cournot model and in the (multiproduct-firm) pricing games with CES and MNL demands. They show that the required synergy level depends on the market shares of the merger partners, but not on those of the non-merging outsiders. Moreover, the required synergy level is the higher, the larger are the market shares of the merger partners; a sum-preserving contraction of the merger partners' market shares also increases the required synergies. These results suggest that the likelihood of a merger harming consumers is positively related to the induced change in the Herfindahl index but unrelated to the level of the index when controlling for the change.[11]

In the empirical part of their paper, Nocke and Whinston (2020) examine the required synergies in the context of 390 potential (local) mergers in the U.S. brewing industry, using the (random-coefficient MNL) demand and marginal cost estimates of Miller and Weinberg

[10] They also provide an approximation around monopolistic competition "conduct".

[11] Nocke and Whinston (2020) exclusively focus on the unilateral price effects of mergers, abstracting from potential coordinated effects. The level of the Herfindahl index would matter for the likelihood of consumer harm if the level of the merger-induced efficiencies, or the probability of merger-induced entry or product-repositioning, depended on industry concentration.

(2017).[12] They find that the required synergy is strongly positively related to the merger-induced change in the Herfindahl index and largely unrelated to the level. Nocke and Whinton (2020) also argue that the presumptions in the 2010 *Horizontal Merger Guidelines* are likely too lax, at least unless one is crediting efficiencies of 5 percent or larger to the typical mergers, or is presuming that other factors such as entry or product-repositioning would prevent any-competitive effects.

2.5 Mergers in open economies

In a globalized world, many firms not only sell in their domestic markets but also abroad. Yet, trade frictions imply that markets are not perfectly integrated internationally. As a result, a merger may raise consumer surplus in one market but reduce it in another.

Breinlich et al. (2020) analyze this issue in a model of international trade with oligopolistic competition.[13] In their baseline, firms compete in a Cournot fashion and markets are segmented; $P^i(\cdot)$ denotes the inverse demand function in country i. Firms incur iceberg-type trade costs when selling in the foreign country. Specifically, for one unit of the output to arrive in country j, a firm located in country i has to ship τ^{ij} units, where $\tau^{ii} = 1$.

Consider a merger M among active firms located in country i, and consider its effect on consumers in country j (which may or may not be equal to i). Adjusting condition (4) to account for trade costs, the merger is CS-neutral in country j if and only if

$$P^j(Q^{j*}) - \tau^{ij}\overline{c}_M = \sum_{f \in M} \left[P^j(Q^{j*}) - \tau^{ij} c_f \right] \tag{10}$$

or, equivalently,

$$\overline{c}_M = \left(\sum_{f \in M} c_f \right) - (|M| - 1) \frac{P^j(Q^{j*})}{\tau^{ij}} \equiv \hat{c}_M^{ij},$$

where $|M|$ denotes the number of merger partners. Hence,

$$\hat{c}_M^{ij} - \hat{c}_M^{ii} = (|M| - 1) \left(P^i(Q^{i*}) - \frac{P^j(Q^{j*})}{\tau^{ij}}. \right)$$

Because markets are segmented (implying that consumer prices in the two countries may differ from each other) and because of trade costs, the post-merger cost threshold below which the merger benefits consumers in the foreign country $j \neq i$, $\hat{c}_M^{ij}$, is likely to differ from that in the home country i. If so, the two countries have potentially conflicting interests: while the merger is CS-nondecreasing in both countries if $\overline{c}_M \leq \min\left(\hat{c}_M^{ij}, \hat{c}_M^{ii}\right)$ and CS-decreasing in both countries if $\overline{c}_M > \max\left(\hat{c}_M^{ij}, \hat{c}_M^{ii}\right)$, it is CS-decreasing in one but CS-increasing in the other if $\min\left(\hat{c}_M^{ij}, \hat{c}_M^{ii}\right) < \overline{c}_M < \max\left(\hat{c}_M^{ij}, \hat{c}_M^{ii}\right)$.

[12] In the Miller and Weinberg (2017) dataset, there are 39 local markets and five firms, amounting to 10 potential mergers in each of the 39 markets.

[13] See Breinlich et al. (2017) for a survey of the literature on horizontal merger policy in open economies.

Breinlich et al. (2020) define the "conflict statistic"

$$\rho^{ij} \equiv \tau^{ij} \frac{P^j(Q^{j*})}{P^i(Q^{i*})}$$

as the price ratio between the foreign market j and the domestic market i, adjusted for trade costs that firms from country i face when exporting to country j. If $\rho^{ij} \geq 1$, then a merger M that is CS-nondecreasing in its home market i is necessarily also CS-nondecreasing in the foreign market j since $\hat{c}_M^{ii} \leq \hat{c}_M^{ij}$ in that case. By contrast, if $\rho^{ij} < 1$ or, equivalently, $\hat{c}_M^{ii} > \hat{c}_M^{ij}$, then merger M may be CS-nondecreasing in market i and CS-decreasing in market j (whereas if it is CS-nondecreasing in market j, it must also be CS-nondecreasing in market i).[14]

That is, if antitrust authorities maximize consumer surplus in their own country, then foreign authorities want to block mergers that have been approved by their domestic authorities only if the value of the conflict statistic is less than one. Importantly, the value of that statistic is market-specific but not merger-specific. Calibrating the model to industry-level data from Canada and the U.S., Breinlich et al. (2020) find that, at current level of trade costs, the conflict statistic exceeds one in the vast majority of markets, so that any potential conflict is of the "too-tough-for-thy-neighbor" type.

3 Endogenous Mergers and Dynamics

A static analysis of the Williamson trade-off ignores that mergers are endogenous and not one-time events. If merger opportunities arise over time and mergers are proposed only if it is in the merger partners' interest, then a merger approval policy based only on whether a merger is anti-competitive given current market structure may not be appropriate. This is for at least two reasons, both due to competitive externalities. First, the approval decision on a merger proposed today will generally affect the profitability of a potential future merger, and therefore the likelihood of the future merger being proposed. Second, the approval decision on a merger proposed today will affect the welfare consequences of a future merger, and therefore the likelihood of the future merger being approved.

3.1 Optimal dynamic merger approval policy

Analyzing the optimal dynamic approval policy in a model in which merger opportunities arise stochastically over time and, in every period, the partners in a feasible merger have to decide whether to propose it, and the antitrust authority has to decide which (if any) of the currently proposed mergers to approve, appears to be a hopelessly complicated problem.

[14] Breinlich et al. (2020) show that the same conflict statistic—with the equilibrium price in each country being replaced by the CES price index in that country—obtains under multiproduct-firm price competition with CES demand.

Nocke and Whinston (2010) show that, under some conditions, this problem has a surprisingly simple solution: An antitrust authority that aims at maximizing (discounted) consumer surplus can achieve its goal by adopting a completely *myopic* merger approval policy, whereby it approves in every period the subset of proposed mergers that maximizes current consumer surplus, completely ignoring the possibility of future mergers. Remarkably, the outcome induced by such a myopic policy is dynamically optimal in a very strong sense: The antitrust authority could not improve upon it even if it had perfect foresight about future merger possibilities (which it does not) nor if it could undo previously approved mergers (which it cannot).

Nocke and Whinston (2020) prove this result in the context of a homogeneous-goods Cournot model with constant returns to scale. There is a set of potential mergers, $M_1, ..., M_N$, that may become available over T periods. The probability that merger M_k becomes feasible in period $1 \leq t \leq T$ is p_{kt}, with $\sum_{t=1}^{T} p_{kt} \leq 1$. Once a merger M_k has become feasible in period t, the merger partners draw their post-merger marginal cost $\overline{c}_{M_k}$ from some set C_{kt}. Firms involved in a feasible but not-yet-approved merger then decide whether or not to propose their merger for approval to the antitrust authority.[15]

Nocke and Whinston (2020) make two conceptually important assumptions. First, mergers that have been rejected in the past can be proposed again. Second, potential mergers are *disjoint* in that every firm is party to at most one potential merger. As we will see, the first assumption implies that the antitrust authority will not regret blocking a merger that would harm consumers at the time of approval whereas the second implies *inter alia* that mergers are not mutually exclusive.

The dynamic optimality of a myopic appoval policy derives from a series of three key results. The first and most immediate one is:

Result 1 (Nocke and Whinston, 2010)**.** *Suppose that merger M_k is CS-nondecreasing given current market structure. Then, merger M_k is profitable in that it raises the joint profit of the merger partners.*

To see this result, recall from equation (4) that, following a CS-neutral merger, the profit margin of the merged firm is equal to the sum of the pre-merger profit margins of the merger partners and, moreover, the merged firm produces the same quantity of output as the merger partners did jointly before the merger. It follows that a CS-neutral merger is profitable. As reducing the marginal cost of a firm raises that firm's equilibrium profit, it also follows that a CS-increasing merger is profitable as well.

The next result uses the following important observation: the threshold post-merger marginal cost level that makes merger M just CS-neutral, $\hat{c}_M$, is strictly increasing in pre-merger aggregate output Q^*. This observation follows from equation (5) and implies a fundamental sign-preserving complementarity of mergers that share the same sign in terms of their consumer surplus effect:

[15]Bargaining between merger partners is efficient so that the merger will be proposed if and only if it is in their joint interest to do so.

Result 2 (Nocke and Whinston, 2010). *Consider two disjoint mergers, M_1 and M_2. If both mergers are CS-nondecreasing (and therefore profitable) in isolation, then each remains CS-nondecreasing (and therefore profitable) once the other merger has been implemented. Conversely, if both M_1 and M_2 are CS-decreasing in isolation, then each remains CS-decreasing once the other one has taken place.*

To see the assertion on the sign-preserving complementarity of CS-nondecreasing mergers, note that merger M_k $(k = 1, 2)$ being CS-nondecreasing means that $\overline{c}_{M_k} \leq \hat{c}_{M_k}$. If the other merger is implemented, aggregate output and thus $\hat{c}_{M_k}$ must weakly increase, implying that the post-merger marginal cost $\overline{c}_{M_k}$ still lies below the (now weakly higher) threshold $\hat{c}_{M_k}$, i.e., M_k must remain CS-nondecreasing given the new market structure. A similar argument implies the sign-preserving complementarity of CS-decreasing mergers.

The observation that $\hat{c}_M$ is strictly increasing in pre-merger aggregate output also means that, by changing aggregate output, a CS-nondecreasing merger can induce a merger that otherwise would have been CS-decreasing to become CS-nondecreasing (and the reverse):

Result 3 (Nocke and Whinston, 2010). *Suppose that merger M_1 is CS-nondecreasing in isolation and merger M_2 is CS-decreasing in isolation but CS-nondecreasing once M_1 has been implemented. Then, merger M_1 remains CS-nondecreasing (and therefore profitable) once M_2 has taken place. Moreover, the joint profit of the partners to M_1 is strictly higher if both M_1 and M_2 take place than if neither does.*

Before providing a sketch of the proof, note that the last part of the result is quite remarkable: after all, once M_1 has been implemented, merger M_2 (by virtue of being CS-nondecreasing) imposes a (weakly) negative externality on the merged M_1. (Moreover, this result extends to any number of mergers: If one merger induces, directly or indirectly, n other mergers to become CS-nondecreasing, the firms involved in the first are still better off if their merger and all of the others take place than if none does, no matter how large is n and even though all of these n other mergers hurt the firms involved in the first.)

To see why Result 3 holds, note that if the mergers are implemented in the order M_1 first and M_2 second, then—at each step—consumer surplus (weakly) increases by assumption. Consider now the thought experiment of implementing the two mergers in the reverse order. Then, by assumption, consumer surplus falls strictly at the first step (when M_2 is implemented) and rises strictly at the second (when M_1 is implemented). That is, once M_2 has taken place, M_1 is CS-increasing (and therefore profitable). Moreover, when M_2 is implemented at the first step, the profit of all the (active) non-merging outsiders (including the firms involved in M_1) strictly increases as M_2 is CS-decreasing when implemented in isolation. Hence, the joint profit of the merger partners in M_1 increases at each step and is therefore higher when both mergers take place than when neither does.

While Nocke and Whinston (2010) derive Results 1 to 3 for the homogeneous-goods Cournot model, Nocke and Schutz (2019) show that these results, and therefore the conclusion on the dynamic optimality of a myopic merger policy, extend to models of multiproduct-firm price competition with (nested) CES and MNL demands.

Suppose the antitrust authority adopts a myopic merger approval policy. To see the intuition for the dynamic optimality of that policy, consider the special case in which there are only two possible mergers, M_1 and M_2, and only two periods, $T = 2$.

Let us ignore for the moment the moral hazard problem, which arises because the antitrust authority can approve only mergers that are proposed. To this end, suppose that in each period every feasible and not-yet-approved merger is indeed proposed. In the special case with only two possible mergers and two periods, for the outcome of the myopic policy not to be dynamically optimal the following must happen: in period 1, only one merger, say M_1, becomes feasible (and is proposed) and, in period, the other merger (M_2) becomes feasible (and is proposed)—and the arrival of this second merger makes the authority regret its decision on M_1.

To see that such an outcome cannot arise, consider first the case in which M_1 is CS-nondecreasing in isolation. Adopting a myopic policy, the antitrust authority would thus approve the merger in period 1, thereby (weakly) raising consumer surplus in period 1. Obviously, implementing M_1 is still the optimal decision from the viewpoint of maximizing consumer surplus in period 2 if merger M_2 does not become feasible in period 2. The same is true if M_2 becomes feasible (and is proposed) but is CS-decreasing given that M_1 has already been implemented, implying that the authority blocks it in period 2; from Result 2 this means that M_2 must be CS-decreasing in isolation, and so period-2 consumer surplus is maximized by implementing M_1 but not M_2. If, on the other hand, M_2 becomes feasible, is proposed and approved in period 2 because it is CS-nondecreasing given that M_1 has already been implemented, then period-2 consumer surplus is maximized by implementing both M_1 and M_2. M_2 must be either CS-nondecreasing in isolation (i.e., even without implementing M_1) or CS-decreasing in isolation but CS-nondecreasing once M_1 has taken place; Results 2 and 3 imply that M_1 remains CS-nondecreasing given that M_2 takes place. In short, no matter what the characteristics are of M_2 in period 2, the antitrust authority will not have ex post regret about having approved a merger in period 1 that was CS-nondecreasing at the time of approval.

Consider next the case in which M_1 is CS-decreasing in isolation, so that the antitrust authority – following a myopic policy – blocks it in period 1. But this is optimal not only from the viewpoint of period-1 consumer surplus but also from that in period 2: as the blocked merger can and will be proposed again in period 2, the authority is free to implement in period 2 the set of mergers that maximizes period-2 consumer surplus. In short, no matter what the characteristics are of M_2 in period 2, the antitrust authority will not have ex post regret about having blocked a merger in period 1 that was CS-decreasing at the time of the decision.

Let us now turn to firms' merger proposal incentives when the antitrust authority adopts a myopic approval policy. Note first that any merger that is approved must be CS-nondecreasing given the market structure at the time of approval—and by Result 1 raise the joint profit of the merger partners—given the market structure at the time of approval. Moreover, as discussed above, a merger that was approved in period 1 must also be CS-nondecreasing (and therefore profitable) in period 2, given period-2 market structure. Market structure is, however, endogenous: by proposing a merger that is approved firms may affect whether another merger is implemented. But if merger M_k is approved, it must be CS-nondecreasing at the time of approval, and therefore raise the post-merger marginal cost threshold $\hat{c}_{M_l}$ below which the other merger M_l is CS-nondecreasing. Hence, proposing a merger can only increase the likelihood that another merger is implemented. If proposing merger M_k does indeed induce the approval of merger M_l, then—from Result 3—the firms involved in M_k are still better off if both mergers take place than if neither does. In short, firms proposal incentives are fully aligned with the interests of a consumer-surplus-oriented antitrust authority.

As mentioned above, a key assumption for the conclusion on the dynamic optimality of a myopic approval policy is that mergers are disjoint in that no firm can be party to more than one potential merger. This assumption may appear reasonable in environments where firms have natural merger partners. In other environments, however, firms may have a choice between alternative merger partners.

3.2 Optimal merger policy with merger choice

Nocke and Whinston (2013) study the optimal merger policy in a static setting in which firms can choose *which* merger to propose. They show that there is a systematic misalignment of firms' proposal incentives with the interests of consumers. To mitigate those, the antitrust authority optimally commits to discriminate against mergers involving larger firms.[16]

In Nocke and Whinston (2013)'s baseline model, firms compete in a Cournot fashion in a homogeneous-goods industry. There is a single acquirer, firm 0, that can make a public take-it-or-leave-it offer to one possible target $k = 1, ..., K$ of its choosing. If the offer is accepted, the merger is proposed for approval to the antitrust authority. Otherwise, or if the proposed merger is blocked, no merger takes place.[17]

The possible targets can be ordered according to their pre-merger marginal cost, with $c_1 > \cdots > c_K$, so that firm 1 is the smallest possible merger partner and firm K the largest. The feasibility and post-merger marginal cost are stochastic and drawn independently across mergers. The post-merger marginal cost of $M_k = \{0, k\}$ is denoted $\overline{c}_{M_k}$, continuously distributed on some interval $[l, h_k]$.

Before the feasibility of mergers, and their associated marginal costs, are realized, the antitrust authority commits to an approval set $\mathcal{A} \equiv \{M_k : \overline{c}_{M_k} \in \mathcal{A}_k\}$, where $\mathcal{A}_k \subseteq [l, h_k]$ for $k \in \{1, ..., K\}$ gives the post-merger marginal cost levels that would lead to approval of merger M_k. If no merger is proposed, the status quo ("null merger") M_0 remains in place.

Let $\Delta CS(M_k)$ and $\Delta\Pi(M_k)$ denote, respectively, the change in consumer surplus and the change in the bilateral profit of firms 0 and k induced by merger M_k.[18] Given an approval

[16] Lyons (2003) also noted a misalignment of interests when firms can choose between alternative mergers, making commitment to a merger approval policy valuable.

[17] That is, the bargaining process takes the form of Segal (1999)'s "offer game." Nocke and Whinston (2013) also consider alternative "scoring-rule" bargaining process, including efficient Coasian bargaining.

[18] $\Delta\Pi(M_k)$ is thus equal to the profit of the merged M_k minus the sum of the pre-merger profits of merger

policy $\mathcal{A}$ and a realized set of feasible mergers $\mathcal{M}$, firm 0 is going to propose the "most profitable", feasible and allowable merger $M^*(\mathcal{F}, \mathcal{A})$, where

$$M^*(\mathcal{M}, \mathcal{A}) = \begin{cases} \arg\max_{M_k \in (\mathcal{M} \cap \mathcal{A})} \Delta\Pi(M_k) & \text{if } \max_{M_k \in (\mathcal{M} \cap \mathcal{A})} \Delta\Pi(M_k) > 0 \\ M_0 & \text{otherwise.} \end{cases}$$

(To see that this is indeed the proposed merger, note that if firm 0 wants to propose merger M_k, it will make an offer to firm k that gives firm k exactly the same profit it would obtain in the absence of a merger. That is, firm 0 extracts all of the bilateral surplus $\Delta\Pi(M_k)$ from merger M_k.) The antitrust authority in turn chooses the approval set $\mathcal{A}$ that maximizes the expected change in consumer surplus, where the expectation is taken with respect to the set of feasible mergers, $\mathcal{M}$. That is, the antitrust authority's problem can be written as:

$$\max_{\mathcal{A}} E_{\mathcal{M}} \left[\Delta CS(M^*(\mathcal{M}, \mathcal{A})) \right].$$

Figure 1 illustrates the support of merger realizations in outcome space $(\Delta\Pi, \Delta CS)$ for the case of four potential mergers ($K = 4$). It is important to highlight three properties illustrated in this figure. First, for each potential merger M_k, the support of possible realizations is an upward-sloping curve in $(\Delta\Pi, \Delta CS)$-space. This *monotonicity property* obtains since a decrease in post-merger marginal cost $\bar{c}_{M_k}$ is associated both with an increase in consumer surplus $\Delta CS(M_k)$ as well as with an increase in the merged firm's profit and thus in $\Delta\Pi(M_k)$. Second, for each M_k, the merger curve intersects the horizontal axis to the right of the origin. This *willingness-to-propose property* follows from the fact that a CS-neutral merger is bilaterally profitable (recall Result 1): if $\Delta CS(M_k) = 0$, then $\Delta\Pi(M_k) > 0$. Third, in the positive orthant of the $(\Delta\Pi, \Delta CS)$-space, the merger curves are ordered in that those corresponding to larger mergers lie to the right of those for smaller mergers. This *ordered bias property* follows from a systematic misalignment of incentives:

Result 4 (Nocke and Whinston, 2013)**.** *Suppose two mergers, M_i and M_j, with $j > i$, induce the same non-negative change in consumer surplus, $\Delta CS(M_i) = \Delta CS(M_j) \geq 0$. Then, the larger merger M_j induces a larger increase in the bilateral profit of the merger partners: $0 < \Delta\Pi(M_i) < \Delta\Pi(M_j)$.*

To get some intuition, suppose first that both mergers M_i and M_j are CS-neutral, $\Delta CS(M_i) = \Delta CS(M_j) = 0$. The increase in the bilateral profit of a CS-neutral merger M_k can be written as[19]

$$\Delta\Pi(M_k) = [P(Q^*) - c_0]\, q_k^* + [P(Q^*) - c_k]\, q_0^*,$$

partners 0 and k.

[19]To see this, note first that the joint pre-merger profit of the two merger partners is $[P(Q^*) - c_0]q_0^* + [P(Q^*) - c_k]q_k^*$. Recall from Section 2.2 that a CS-neutral merger does not change the merger partners' joint equilibrium output nor aggregate equilibrium output. The merged firm's profit is therefore given by $[P(Q^*) - \bar{c}_{M_k}](q_0^* + q_k^*) = [P(Q^*) - c_0 + P(Q^*) - c_k](q_0^* + q_k^*)$, where the equality follows from equation (4).

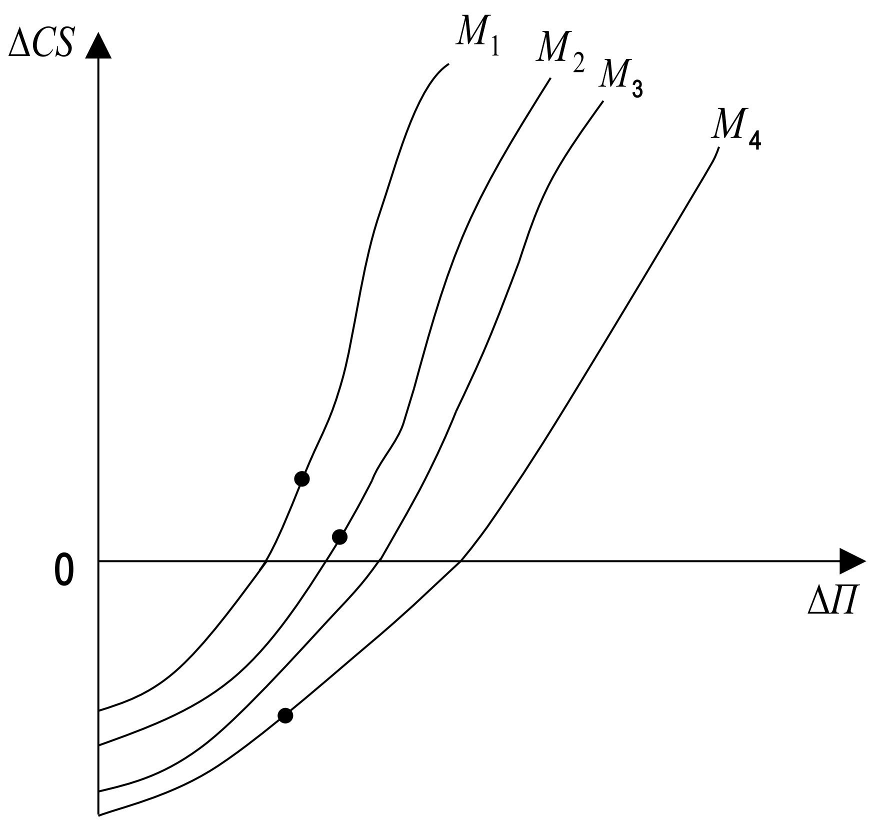

Figure 1: Each curve labeled M_k depicts the relationship between the change in consumer surplus and the change in bilateral profit for a merger between firms 0 and k, with each point on the curve corresponding to a different realization of merger M_k's post-merger marginal cost. The heavy dots illustrate one possible realization (with no feasible merger M_3).

where Q^* and q_k^* denote pre-merger aggregate and firm-k output, respectively. Noting that $c_i > c_j$ and $q_i^* < q_i^*$, we obtain $0 < \Delta\Pi(M_i) < \Delta\Pi(M_j)$. The result can be shown to extend to CS-increasing mergers by proving that $\Delta\Pi(M_j) - \Delta\Pi(M_i)$ increases with an increase in the post-merger aggregate output.

Returning to Figure 1, the dots represent one possible realization of feasible mergers, namely CS-increasing mergers M_1 and M_2, no feasible merger M_3 (illustrated by the absence of a dot), and a CS-decreasing merger M_4. If all three feasible mergers were allowable (i.e., if all were in set $\mathcal{A}$), then merger M_2 would be proposed (and approved) as it is the feasible merger with the largest increase in the merging firms' bilateral profit $\Delta\Pi$. However, from the viewpoint of the antitrust authority, the best merger is M_1 as it is the feasible merger with the largest increase in consumer surplus ΔCS.

The problem faced by the antitrust authority is that it has to choose an approval set before knowing the realization of feasible mergers. In choosing whether to include a particular merger M_k (or, rather, a small interval of mergers around a particular point on the merger curve), the antitrust authority has to condition on the event that this is the most profitable allowable merger as the choice matters only in that event.

A "naive" approval policy would allow all CS-nondecreasing mergers. This is indeed optimal for the approval set A_1 pertaining to the smallest merger M_1: any CS-nondecreasing merger M_1 that is the most profitable allowable merger would, by Result 4, necessarily also be the best for consumers. However, this does not hold for any larger merger M_k, $k > 1$. For example, including the realized merger M_2 in Figure 1 in the approval set may not be optimal: the merger raises consumer surplus by not much; if the authority commits to blocking it, the expected increase in consumer surplus—conditional on that merger otherwise (i.e., if it were included in $\mathcal{A}$) being the most profitable one—may well be larger as, with some probability, a less profitable but better-for-consumers merger M_1 may be feasible.

Let $\underline{\Delta CS}_k$ denote the change in consumer surplus induced by the merger M_k with the highest allowable post-merger cost level $\bar{c}_{M_k}$. That is, $\underline{\Delta CS}_k$ gives the minimum consumer surplus increase necessary for merger M_k to be included in the approval set. Nocke and Whinston (2013) show that the optimal merger approval policy blocks some mergers that would increase consumer surplus, requires a higher minimum standard for larger mergers, and may always block the largest possible merger(s):[20]

Result 5 (Nocke and Whinston, 2013)**.** *Any optimal approval policy $\mathcal{A}$ has the following properties:*

1. *it approves the smallest merger M_1 if and only if is CS-nondecreasing;*

2. *only mergers $M_1, ..., M_{\hat{K}}$, where $\hat{K} \leq K$, are approved with positive probability;*

[20]The optimal approval policy does not necessarily have a cutoff structure in that it may be optimal to commit to approving merger M_k when it would raise consumer surplus by $\Delta CS \geq \underline{\Delta CS}_k$ but block it when it would raise it by $\Delta CS' > \Delta CS$. However, Nocke and Whinston (2013) provide a condition under which the optimal policy does have a cutoff structure.

3. *the minimum increase in consumer surplus necessary for a merger to be included in the approval set is higher for larger mergers:* $0 = \underline{\Delta CS}_1 < \underline{\Delta CS}_2 < \cdots < \underline{\Delta CS}_{\hat{K}}$.

Nocke and Whinston (2013) show that the conclusion continues to hold for alternative merger bargaining processes (notably, industry-wide Coasian bargaining), alternative welfare standards (notably, a weighted average of consumer surplus and aggregate surplus), and differentiated-products price competition (with CES or MNL demands).

3.3 Dynamic merger policy with endogenous investment

Reflecting both the academic literature and antitrust practice, the discussion so far has focused on the short-run price (or quantity) effects of mergers. However, mergers also affect firms' incentives to invest, to innovate, or to shape product characteristics. Such long-run effects are much less well understood, and harder to quantify, than the short-run price effects though—explaining why such effects have for a long time been ignored. In recent years, however, mergers' investment effects have played an important role in a number of merger investigations, not least in a series of mobile telephony mergers in the EU and the U.S. as well as in the European Commission's investigation of the DowChemical/DuPont merger.

In recent work, Motta and Tarantino (2018) and Bourreau et al. (2019) analyze the investment effects of mergers in static models of price (or quantity) competition, enriched by investment in cost reduction or quality improvement. While such static models have the advantage of tractability, they may appear less appropriate when analyzing the effect of policy on long-run decisions such as investments. What is taken as given in a static model—the initial state of the industry (e.g., the initial vector of marginal costs)—is affected by policy in a dynamic model.

Mermelstein et al. (2020) analyze merger policy in a dynamic computational model in which firms can reduce their marginal costs by investing in capital or by combining capital through mergers. Firms compete in quantities in a homogeneous-goods industry, using an increasing returns-to-scale technology that combines labor and capital. The model builds on the computational literature on industry dynamics pioneered by Pakes and McGuire (1994) and Ericson and Pakes (1995) but amends the investment and depreciation technologies to make the model more appropriate for merger analysis. In particular, Mermelstein et al. (2020) assume the following. First, each unit of capital that a firm owns depreciates with some probability (the realization of which is independent across capital units). Second, for each unit of capital that a firm owns, it receives an independent random cost draw at which the firm can choose to augment that unit of capital by adding a second.[21] In conjunction, these two assumptions imply that investment and depreciation are "merger neutral" in that mergers do not change the investment opportunities that are available in the market. Moreover, compared to the literature building on Pakes and McGuire (1994) and Ericson and Pakes

[21] To allow for entry of new firms with no initial capital, Mermelstein et al. (2020) also introduce the possibility of "greenfield investment". Such greenfield investment is, however, associated with higher costs.

(1995), the investment technology allows for much richer investment dynamics.[22].

Firms can add to their capital (and reduce their marginal cost) not only by investing ("internal growth") but also by merging and combining their capital stocks ("external growth"). The decision to propose a merger is endogenous and determined by a bargaining process. While Mermelstein et al. (2020) also consider the case of a commitment policy, their analysis focuses on the case in which the antitrust authority is a strategic player, endowed with an objective function (discounted consumer surplus or discounted aggregate surplus) but without the power to commit to its future policy.

The key insights of Mermelstein et al. (2020) may be summarized as follows. First, the desirability of approving a proposed merger crucially depends on the impact that this decision has on future investment behavior, not only of the merger partners but also of non-merging outsiders. In Mermelstein et al. (2020), approving a merger often leads to higher investments by new entrants or small firms, a form of "entry for buyout" (Rasmusen, 1988), and such behavior can come at a significant welfare cost. Second, investment behaviors can be greatly impacted by firms' beliefs about future merger policy. In particular, if the antitrust authority adopts a more permissive merger policy, this will spur entry-for-buyout behavior by firms seeking to be acquired. Third, the optimal merger approval policy under commitment may be very different from the policy that an antitrust authority adopts if it cannot commit. In the absence of commitment power, it may therefore be optimal to endow the authority with a tougher welfare standard. This may help explain why in many jurisdictions authorities have adopted a consumer-surplus rather than aggregate-surplus standard. Fourth, in Mermelstein et al. (2020), the optimal dynamic policy is markedly different from the optimal static policy that considers the effect of the merger only at the current state. Finally, externalities on non-merging rivals can have strong effects on firms' investment incentives and thereby shape the optimal merger approval policy.

4 Avenues for Future Research

The above discussion of recent advances in the analysis of horizontal merger policy has left out some important issues.

Merger control involves not only the binary choice between blocking and approving a proposed merger. Rather, the antitrust authority has a much richer tool kit: it can make its approval decision subject to behavioral remedies (e.g., the licensing of intellectual property) or structural remedies (e.g., the divestiture of tangible assets). Indeed, antitrust authorities are much more likely to impose such remedies than to block a merger: Affeldt et al. (2018) report that, between 1990 and 2014, the European Commission approved 15 times more mergers subject to remedies than it prohibited.

Despite this, surprisingly little is known about the optimal design of such remedies (and

[22]In that literature, firms can add at most one unit of capital in each period, so that a merger reduces the investment opportunities not only for the merging firms but also for the market.

their empirical effects).[23] Some researchers have tried to understand the conditions under which divestitures can eliminate any harm that a merger would otherwise inflict on consumers. While Vergé (2010) provides an interesting benchmark case, it should be clear that little can be said in general—unless one is willing to impose strong assumptions on how the asset divestitures affect the efficiency of the merger partners as well as the efficiencies of the acquirers of the divested assets.

Nocke and Rhodes (2019) develop a framework to analyze remedies of mergers that may cross different markets. They impose only mild (monotonicity) assumptions on how the divestitures of (market-specific) assets affect the marginal costs of the divesting merger partners and those of the asset-receiving outsiders. At the heart of their analysis is the *remedies exchange rate*, which gives the amount of profit that the merger partners would have to give up to achieve an extra dollar of consumer surplus. They investigate how the remedies exchange rate varies with the level of divestitures within a market and how it varies across markets that differ in the intensity of competition.

As touched upon in the introduction, the coordinated effects of mergers are much less well understood, both theoretically and empirically, than the unilateral effects of mergers. Much of the common intuition for the coordinated effects of horizontal mergers stems from the textbook model of an infinitely-repeated, homogeneous-goods Bertrand game: in that model, the critical discount factor is strictly increasing in the number of (symmetric) firms – suggesting that a merger that reduces the number of players facilitates collusion. As Compte et al. (2002) show, however, this intuition may be incorrect once firms are (differentially) capacity constrained and a merger allows firms to combine their capacities. In their model, a merger may increase or reduce the critical discount factor, depending on merger and market characteristics. More work along these lines in richer models of competition would be most welcome.

Two objections against such an approach may be raised though. First, the standard repeated-game framework provides an embarrassment of riches in the form of a huge multiplicity of equilibria. Applied researchers have responded to this by focusing on the "best" (or "most collusive") equilibrium, albeit without much in terms of empirical support. Second, in the industrial organization literature, a merger (or some other change in market structure) is typically said to facilitate collusion if it raises the critical discount factor above which the monopoly outcome can be supported. But what does such a reduction in the critical discount factor mean if the true discount factor is well above that level? To address that second objection, it would seem desirable to turn the focus to richer models with imperfect monitoring.

Finally, much more (empirical) work is needed on merger-induced synergies and on understanding the extent to which entry, product repositioning and other factors tend to ameliorate the unilateral anti-competitive effects of mergers.

[23] A notable exception, Friberg and Romahn (2015) empirically study the effect of a merger among brewing companies that involved the required divestiture of 18 products to a small rival firm. They also perform a structural simulation, both with and without divestitures.

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