Concentration Screens for Horizontal Mergers*
(First draft)

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1 Introduction

Concentration measures play a central role in merger analysis. The current Department of Justice and Federal Trade Commission *Horizontal Merger Guidelines* state various presumptions – both safe harbor presumptions and presumptions of anticompetitive effects – based on the level of the post-merger Herfindahl index and the change that the merger induces in that index (both naively computed, by adding the merging firms' pre-merger shares together). While many other factors come into play in the agencies' analyses, these concentration-based presumptions have a significant impact on agency decisions. Moreover, when the agencies challenge mergers in Court, these concentration measures are frequently emphasized by the agencies, and often factor significantly in courts' decisions. Surprisingly, perhaps, the basis for these presumptions in both form and level is rather unclear.[1]

In this paper, we examine these presumptions, focusing on a merger's likely unilateral effects.[2] We make two points: First, we show that there is both a theoretical and an empirical basis for focusing solely on the change in the Herfindahl index, and ignoring its level, in screening mergers for whether they will harm consumers. Second, we argue, again both theoretically and empirically, that the levels at which the presumptions currently are set may well be too lax, especially in creating a safe harbor based on the post-merger Herfindahl index, at least unless one is crediting a significant presumption that entry,

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[1] See Schmalensee (1987, pp. 47-50) for one previous discussion of the *Guidelines* concentration thresholds.

[2] Miller and Weinberg (2017) provide evidence that horizontal mergers may also lead to coordinated effects, as noted in the agencies' *Guidelines*.

repositioning, or other factors would prevent any anti-competitive effects of the typical merger.

The paper is organized as follows. In Section 2, we review the history of concentration screens in the various versions of the *Horizontal Merger Guidelines*.

In Section 3, we examine two canonical models of competition in which one might hope that there would be a clear relationship between equilibrium concentration measures and the effect of a merger on consumer surplus: the Cournot model and the multinomial Logit model. Our focus in this analysis is on the level of marginal cost reduction (the "synergy" or "efficiency gain") required to prevent a merger from harming consumers. We show that this critical level of efficiencies depends in these models on the merging firms' shares, but not on the shares of non-merging firms. In fact, for mergers between symmetric firms in the Cournot model, given the market demand elasticity, the required synergy depends solely on the (naively-computed) change in the Herfindahl index, and not at all on its post-merger level. We also show that, at least in these two models, prevention of consumer harm likely requires much more stringent thresholds than in the agencies' current 2010 *Guidelines*. Indeed, with synergies of less than 5%, consumer harm occurs when the merging firms' shares are much like those in the 1968 *Guidelines*' thresholds. Finally, we note that one might make sense of merger screens based on non-merging firms' shares (e.g., based on the post-merger Herfindahl index) if one is willing to accept mergers that harm consumers to some limited extent.

The theoretical models of Section 3 are certainly special. In Section 4, we provide an empirical investigation of how mergers' effects on consumers are related to concentration measures in one industry. We focus on possible mergers in brewing. Using the estimated demand system in Miller and Weinberg (2017), a random-coefficient nested Logit demand system that is not covered by our theoretical analysis, and treating each local market separately, we compute for various hypothetical (local) mergers the efficiency improvement that would be required to prevent consumer harm. The results show that, as in the models of Section 3, the required efficiency gain is strongly related to the (naively computed) change in the Herfindahl index and hardly related to the level of the post-merger Herfindahl (once one conditions on the change in the Herfindahl). However, the thresholds we see for consumer harm appear less stringent than in the theoretical models of Section 3 and present a more nuanced picture with regard to the current 2010 *Guidelines*: With synergies between 1-5%, there are a good number of mergers that harm consumers but fall into current safe harbors by having a Herfindahl below 1500, but there are also mergers that are presumed to be anti-competitive because of post-merger Herfindahl indices above 2500 that would benefit consumers. However, to the extent that mergers that fall within safe harbors are simply allowed without further scrutiny, while those that fall into the anticompetitive presumption are scrutinized further and may be allowed based on that further analysis, this may result in too lax a policy.

We conclude in Section 5. Overall, given these results we see it as likely

that for evaluating unilateral effects the form of current concentration screens should be modified to focus more on the change in the Herfindahl index and less on its post-merger level, probable that current safe harbors are allowing mergers to proceed that lead to consumer harm, and possible that current concentration screens are more generally too lenient.

2 History of the Merger Guideline Concentration Screens

The first version of the *Merger Guidelines* – issued solely by the Department of Justice, appeared in 1968, shortly after the 1963 Philadelphia National Bank decision and roughly contemporaneous with the Neal Report. As described by Shapiro (2010), the 1968 *Guidelines* approach toward horizontal mergers was focused entirely on preventing increases in concentration and it proposed concentration thresholds that were markedly more stringent than those today. The presumptions were largely dependent on the shares of the two merging firms. For mergers in markets in which the four-firm concentration ratio was above 75%, a merger would be blocked if a firm with a 4% share wanted to acquire another firm with a 4% share, and a firm with a 15% share could not acquire a firm with a 1% share.[3] For markets with a four-firm concentration ratio below 75%, the thresholds were not much more lenient: a merger between two 5% firms would be blocked.

The DOJ's 1982 Guidelines represented a marked change, with the Herfindahl index (HHI) replacing the four-firm concentration ratio, but more importantly with the level of market concentration having much more importance, and with much more lenient standards.[4] For example, a merger between two 5% share firms, rather than being challenged became presumptively legal. More specifically, mergers were presumptively legal if the post merger HHI (measured out of 10,000) was below 1000 or if the change in the HHI was below 50, and presumptively illegal if both the post-merger HHI was above 1800 and the change in the HHI was above 100. For "moderately concentrated markets" with post-merger Herfindahl indices between 1000 and 1800, the merger was unlikely to be challenged if the change in the Herfindahl was below 100, and "more likely than not" to be challenged if it was above 100. The 1992 *Horizontal Merger Guidelines*, issued for the first time jointly by the DOJ and FTC, maintained these presumptions.[5]

[3] Somewhat curiously, the 1968 screens depended on which merger partner was the acquirer.

[4] Shapiro (2010) describes well the other significant innovations in the 1982 *Guidelines*, and the continuing increase over time in consideration of other market factors in analyzing prospective mergers.

[5] The 1992 *Guidelines* did change "more likely to be challenged than not" to "potentially raise significant competitive concerns." The 1982 *Guidelines* also had a presumption of anti-competitive harm, eliminated in the 1992 *Guidelines*, if the acquirer was the leading firm in the industry, had a share of at least 35%, was more than twice as large as the second largest firm, and was acquiring a firm with at least a 1% share.

Most recently, the 2010 revision of the *Horizontal Merger Guidelines* relaxed these standards, raising the safe harbor level of the HHI from 1000 to 1500, the threshold for considering a market highly concentrated from 1800 to 2500, and the critical levels of change in the HHI in highly concentrated markets from 50 to 100 for the safe harbor, and from 100 to 200 for the presumption of harm (thresholds in moderated concentrated markets were not changed).

Notably, the theoretical and empirical basis for neither the 1968 *Guidelines* nor the 1982 changes were ever clearly laid out by the agencies; the change in 2010, on the other hand, was made explicitly in an effort to enhance transparency by making the thresholds conform more closely with actual agency practice (see Shapiro (2010)).

On point to note, however, is that the safe harbor and anti-competitive presumptions are not symemtric in the following sense: mergers which fall into the safe harbor, perhaps because of a low post-merger Herfindahl index, are typically simply allowed without further scrutiny, while those which fall into the anticompetitive presumption category are scrutinized further and may be allowed based on other factors.

3 Theoretical Analysis

Analysis of horizontal mergers focuses on weighing the risk of anticompetitive reductions in competition against the prospect for merger-related efficiencies. Concentration screens for mergers must therefore aim to capture, based on firms' market shares, the likely balance of these two effects for the "typical" merger. Since absent any efficiency gains a horizontal merger will generally (weakly) increase prices, any merger screen that would allow some mergers and block others must implicitly be relying on some presumption of the efficiency gain that, on average, should be credited to a typical merger. As such, we focus throughout the paper on how the required efficiency gain is related to measures of concentration.

In general, models of oligopolistic competition need not produce a clean relationship between the effect of a merger and market shares, let alone concentration measures such as the Herfindahl index. In this section, however, we focus theoretically on two models that do, the Cournot model and the multinomial Logit model of price competition.

3.1 Mergers in the Homogeneous-Goods Cournot Model

Consider an industry with a set $\mathcal{F}$ of firms producing a homogeneous good with constant returns to scale and competing in a Cournot fashion. Let c_f denote the (constant) marginal cost of firm $f \in \mathcal{F}$, and $P(Q)$ inverse demand, where Q is aggregate output. We impose standard assumptions ensuring that there exists a unique Nash equilibrium in quantities: that for any Q such that $P(Q) > 0$, we have $P'(Q) < 0$ and $P'(Q) + QP''(Q) < 0$; moreover, $\lim_{Q\to\infty} P(Q) = 0$.

Let Q^* denote the pre-merger aggregate equilibrium output. For simplicity, we assume that all firms in $\mathcal{F}$ are active before the merger in that $\max_{f\in\mathcal{F}} c_f < P(Q^*)$. The pre-merger market share of firm f, s_f, satisfies

$$s_f = -\frac{P(Q^*) - c_f}{Q^* P'(Q^*)},$$

and the pre-merger Herfindahl index is given by $H = \sum_{f\in\mathcal{F}} s_f^2$.

Consider a merger $M = \{n, m\}$ between firms m and n. Given their pre-merger market shares s_m and s_n, their combined pre-merger market share is $s_M \equiv s_m + s_n$. The naively-computed post-merger Herfindahl index is given by

$$\overline{H} = s_M^2 + \sum_{f\in\mathcal{F}\setminus M} s_f^2,$$

and the naively-computed merger-induced change in the index by $\Delta H \equiv \overline{H} - H = 2s_m s_n$. For reasons that will become clear later, let $H_M \equiv (s_m^2 + s_n^2)/s_M^2$ denote the *within-merger* Herfindahl index, whose value lies between 1/2 and 1, and let

$$c_M = \frac{s_m c_m + s_n c_n}{s_M}.$$

denote the output-weighted average marginal costs of the merger partners prior to the merger. We denote the merged firm's post-merger marginal cost by $\overline{c}_M$.

We seek to relate the merger-induced efficiency gains necessary to make the merger have no effect on consumer surplus — that is, to be "CS-neutral" — to the pre-merger market structure.[6] Recall from Farrell and Shapiro (1990) (see also Nocke and Whinston (2010)) that merger M is CS-neutral if and only if

$$P(Q^*) - \overline{c}_M = [P(Q^*) - c_m] + [P(Q^*) - c_n]. \tag{1}$$

It is instructive to begin with the simple case in which the two merger partners are symmetric: $c_m = c_n \equiv c_M$ and thus $s_m = s_n \equiv s_M/2$. Using equation (1), the merger is CS-neutral if the fractional change in the merger partners' marginal cost satisfies

$$\frac{c_M - \overline{c}_M}{c_M} = \frac{P(Q^*) - c_M}{c_M}. \tag{2}$$

From the merger partners' pre-merger first-order conditions, we have

$$c_M = P(Q^*)\left[1 - \frac{s_M}{2\epsilon}\right],$$

[6] Under the regularity conditions we assume, a reduction in a firm's marginal cost expands output and lowers price. Thus, any larger synergy than that required for CS-neutrality will result in the merger benefiting consumers, while any lower synergy will result in the merger harming consumers.

where $\epsilon \equiv -P(Q^*)/[Q^*P'(Q^*)]$ is the pre-merger price elasticity of demand. Substituting for c_M on the right-hand side of equation (2), we obtain

$$\frac{c_M - \overline{c}_M}{c_M} = \frac{\frac{s_M}{2\epsilon}}{1 - \frac{s_M}{2\epsilon}} = \frac{\sqrt{\frac{\Delta H}{2}}}{\epsilon - \sqrt{\frac{\Delta H}{2}}}. \tag{3}$$

That is, for a given demand elasticity, the required efficiencies are perfectly related to and increasing in the naively-computed *change* in the Herfindahl index, and *completely independent of the level* of the Herfindahl index. Any relationship between consumer harm and the level of the Herfindahl would therefore need to come through a relationship between the Herfindahl and the elasticity of demand.[7]

The change in the Herfindahl required to prevent harm to consumers at various levels of the market demand elasticity and efficiency gain are also striking if one views the merging firms achieving a 5% synergy as fairly optimistic for the typical horizontal merger. Table 1 shows these levels, while Table 2 gives the corresponding market share levels for the merging firms. For example, in a market with a demand elasticity of 1.5, a merger of symmetric firms that results in a 5% synergy would lower consumer surplus if the (naively-computed) change in the Herfindahl exceeds 102, which corresponds to the merging firms having roughly a 7% share. Were the industry symmetric, that would be a market with 13 firms. With a 2% synergy the change in the Herfindahl would need to be below 38 to prevent consumer harm, regardless of the level of the post-merger Herfindahl. This is a level similar to that in the 1968 *Guidelines*. Still, in markets in which the elasticity of demand reaches 2.5, with a 5% synergy some mergers that fall into the anticompetitive presumption category of the 2010 *Guidelines* because they have a post-merger Herfindahl above 2500 and a change in the Herfindahl above 200 would actually be beneficial for consumers (if $\Delta H < 283$).

Table 1: $\Delta H * 10,000$ for no consumer harm from a symmetric-firm merger in a Cournot market

		Synergy						
		1%	**2%**	**3%**	**4%**	**5%**	**7.5%**	**10%**
Market	**1**	2	7	17	30	45	97	165
Demand	**1.5**	4	17	38	67	102	219	372
Elasticity	**2**	8	30	68	118	181	389	661
	2.5	12	48	106	184	283	608	1033

[7] Under the standard regularity conditions we assume, an increase in output raises the elasticity of demand. Hence, there may be a positive association between H and ϵ, holding ΔH fixed, because of the effect of markets with larger numbers of non-merging firms having lower prices. At the same time, markets with more elastic demand may see less entry, possibly causing the reverse relationship.

Table 2: Merging firm individual shares (*100) for no consumer harm from a symmetric-firm merger in a Cournot market

		Synergy						
		1%	**2%**	**3%**	**4%**	**5%**	**7.5%**	**10%**
Market	**1**	1	2	3	4	5	7	9
Demand	**1.5**	1	3	4	6	7	10	14
Elasticity	**2**	2	4	6	8	10	14	18
	2.5	2	5	7	10	12	17	23

Proposition 1 shows how this result generalizes to the case of mergers between asymmetric firms.

Proposition 1 *For merger M to be CS-neutral, the merger-induced efficiencies have to satisfy:*

$$\frac{c_M - \overline{c}_M}{c_M} = \frac{\left(\sqrt{\frac{\Delta H}{2}}\right)\left(\sqrt{2(1-H_M)}\right)}{\epsilon - \left(\sqrt{\frac{\Delta H}{2}}\right)\left(\frac{H_M\sqrt{2}}{\sqrt{1-H_M}}\right)}. \tag{4}$$

Proof. We have

$$\begin{aligned}
\frac{c_M - \overline{c}_M}{c_M} &= \frac{s_m c_m + s_n c_n - s_M \overline{c}_M}{s_m c_m + s_n c_n} \\
&= \frac{s_m c_m + s_n c_n - s_M[c_m + c_n - P(Q^*)]}{s_m c_m + s_n c_n} \\
&= \frac{s_n[P(Q^*) - c_m] + s_m[P(Q^*) - c_n]}{s_m c_m + s_n c_n} \\
&= \frac{s_n P(Q^*)\frac{s_m}{\epsilon} + s_m P(Q^*)\frac{s_n}{\epsilon}}{s_m P(Q^*)[1 - \frac{s_m}{\epsilon}] + s_n P(Q^*)[1 - \frac{s_n}{\epsilon}]} \\
&= \frac{\frac{2 s_m s_n}{\epsilon}}{s_M\left[1 - \frac{s_m^2 + s_n^2}{s_M \epsilon}\right]} \\
&= \frac{\frac{\Delta H}{s_M}}{[\epsilon - s_M H_M]} \\
&= \frac{\left(\sqrt{\frac{\Delta H}{2}}\right)\left(\sqrt{2(1-H_M)}\right)}{\epsilon - \left(\sqrt{\frac{\Delta H}{2}}\right)\left(\frac{H_M\sqrt{2}}{\sqrt{1-H_M}}\right)},
\end{aligned} \tag{5}$$

where the first equality follows from the definition of c_M, the second from equation (1), the fourth from the pre-merger first-order conditions, and the last from substituting for s_M using the fact that since

$$\Delta H = (s_M)^2(1 - H_M) \tag{6}$$

we have

$$s_M = \sqrt{\frac{\Delta H}{(1 - H_M)}}.$$

■

Intuitively, one would expect that, holding the change in the Herfindahl index fixed, the required efficiency shrinks as the merging firms become more asymmetric. (When one of the merging firms has zero share, there is no anti-competitive effect of the merger even absent synergies.) The following corollary confirms this.

Corollary 1 *In the Cournot model, the marginal cost reduction required to prevent a reduction in consumer surplus falls with a sum-preserving spread of the merging firms' shares.*

Proof. Substituting for H_M in expression (5) using the fact that (6) implies that

$$H_M = 1 - \frac{\Delta H}{(s_M)^2}$$

yields that

$$\frac{c_M - \overline{c}_M}{c_M} = \frac{\Delta H}{s_M(\epsilon - s_M) + \Delta H}.$$

Holding s_M fixed, the right-hand side is increasing in ΔH, which reaches its maximum when the merging firms are symmetric and is monotonically decreasing as they become more asymmetric. ■

3.2 Mergers in Multiproduct-Firm Price Competition with Multinomial Logit Demand

Consider now an industry with a set $\mathcal{N}$ of horizontally differentiated products.[8] The demand for product $k \in \mathcal{N}$ is of the multinomial Logit form:

$$D^k(p) = \frac{\exp\left(b^k - p^k\right)}{\sum_{j \in \mathcal{N}} \exp\left(b^j - p^j\right)},$$

where b^j and p^j are the quality and price of product j, respectively. Consumer surplus is given by $CS(A) = \log A$, where

$$A \equiv \sum_{j \in \mathcal{N}} \exp\left(b^j - p^j\right)$$

is the value of the "aggregator."

The set of firms, $\mathcal{F}$, is a partition of $\mathcal{N}$; that is, each product is offered by only one firm but each firm may sell multiple products. (We assume that there are at least three firms prior to the merger: $|\mathcal{F}| \geq 3$.) Firms have constant returns to scale; the (constant) marginal cost of product k is $c^k > 0$. Firms compete in prices.

[8] The equilibrium analysis here closely follows Nocke and Schutz (2018).

At price vector p, firm f's profit is given by

$$\Pi_f(p) = \sum_{k \in f} (p^k - c^k) D^k(p).$$

From the first-order conditions of profit maximization, it can be shown that firm f sets the same absolute markup $\mu_f > 0$ on each of its products,

$$p^j - c^j = \mu_f \quad \forall j \in f,$$

and that firm f's markup μ_f satisfies (see Nocke and Schutz (2018))

$$\mu_f \left(1 - \frac{T_f}{A} \exp(-\mu_f)\right) = 1, \tag{7}$$

where

$$T_f \equiv \sum_{k \in f} \exp\left(b^k - c^k\right)$$

is firm f's 'type' (which is equal to the firm's contribution to the aggregator — and thus to consumer surplus — if it were to price all of its products at marginal cost). Equation (7) has a unique solution in μ_f, denoted $m(T_f/A)$. The function $m(\cdot)$ is called the *markup fitting-in function*. It is strictly increasing, $m'(\cdot) > 0$: Firms with higher types (larger T) or facing less competition (lower A) charge higher markups.

The market share of product k, s^k, is equal to $s^k = \exp(b^k - p^k)/A$, and the market share of firm f can be shown to satisfy

$$s_f = \frac{T_f}{A} \exp\left(-m\left(\frac{T_f}{A}\right)\right) \equiv S\left(\frac{T_f}{A}\right). \tag{8}$$

$S(\cdot)$ is called the *market share fitting-in function*; it is strictly increasing: $S'(\cdot) > 0$. Combining equations (7) and (8), we obtain a monotonic relationship between firm f's markup μ_f and its market share s_f:

$$\mu_f = \frac{1}{1 - s_f}.$$

The equilibrium aggregator level A^* is the unique solution in A to the market shares adding up to unity:

$$\sum_{f \in \mathcal{F}} S\left(\frac{T_f}{A}\right) = 1.$$

Consider now merger M between firms m and n. The post-merger equilibrium value of the aggregator, $\overline{A}^*$, then satisfies

$$S\left(\frac{\overline{T}_M}{\overline{A}^*}\right) + \sum_{f \notin M} S\left(\frac{T_f}{\overline{A}^*}\right) = 1,$$

where $\overline{T}_M$ is the merged firm's type. (If the merged firm were to produce exactly the same product lines as the merger partners did jointly before the merger, at the same vector of marginal costs, then we would have $\overline{T}_M = T_m + T_n$.) Hence, the merger is CS-neutral, $\overline{A}^* = A^*$, if $\overline{T}_M$ is such that

$$S\left(\frac{\overline{T}_M}{A^*}\right) = S\left(\frac{T_m}{A^*}\right) + S\left(\frac{T_n}{A^*}\right). \tag{9}$$

As shown in Nocke and Schutz (2019), for merger M to be CS-neutral, it must involve synergies in that $\overline{T}_M > T_m + T_n$.[9]

We obtain the following analog of Proposition 1:[10]

Proposition 2 *For merger M to be CS-neutral, the merger-induced type synergy has to satisfy:*

$$\frac{\overline{T}_M}{T_m + T_n} = \frac{s_M \exp\left(\frac{1}{1-s_M}\right)}{s_m \exp\left(\frac{1}{1-s_m}\right) + s_n \exp\left(\frac{1}{1-s_n}\right)}. \tag{10}$$

Proof. From equation (8), we have

$$\frac{T_f}{A} = S^{-1}(s_f),$$

implying that

$$\frac{\overline{T}_M}{T_m + T_n} = \frac{S^{-1}\left(s_m + s_n\right)}{S^{-1}\left(s_m\right) + S^{-1}\left(s_n\right)}.$$

Next, from equation (7),

$$\begin{aligned}\frac{T_f}{A} &= \exp(\mu_f)\left(1 - \frac{1}{\mu_f}\right) \\ &= \exp\left(1 - \frac{1}{s_f}\right) s_f.\end{aligned}$$

Hence, $S^{-1}(s_f) = s_f \exp(1/(1-s_f))$, implying the result. ■

Proposition 2 implies that the required synergy (in terms of an improvement to the merging firms' types) can be written solely as a function of the pre-merger market shares of the merger partners. Unlike the Cournot case, even with symmetric firms this does not mean that the required efficiency depends on the change in the Herfindahl; it is some other function of the merging firms' market shares.

However, an analog to Corollary 1 obtains:

[9] As $S(0) = 0$ and $S''(\cdot) < 0$, the market share fitting-in function S is sub-additive. The result then follows from equation (9).

[10] The same result holds with an outside good, but in that case shares are "comprehensive" shares (i.e., include the outside good choice probability in the denominator).

Corollary 2 *In the Logit model, a sum-preserving spread of the merger partners' pre-merger market shares reduces the efficiencies required to prevent consumer harm.*

Proof. The second part follows from the strict concavity of the function $S(\cdot)$. ■

Table 3 depicts, for various synergy levels, the critical change in the Herfindahl index from a symmetric-firm merger above which the merger would harm consumers.[11] Table 4 depicts the corresponding market shares of each merger partner. Even mergers among small firms would require substantial synergies for the merger to be CS-neutral. In fact, the numbers are somewhat starker than in the Cournot model with a market elasticity of 1. For example, a merger between two firms with a 5% pre-merger market share each (raising the Herfindahl index by 50) would require synergies exceeding 5%. These are numbers quite close to the 1968 *Guidelines*.

Table 3: $\Delta H * 10,000$ for no consumer harm from a symmetric-firm merger in a Logit market

		Synergy				
1%	**2%**	**3%**	**4%**	**5%**	**7.5%**	**10%**
1.9	7.0	14.8	24.8	36.5	71.6	112.4

Table 4: Merging firms' individual shares (*100) for no consumer harm from a symmetric-firm merger in a Logit market

		Synergy				
1%	**2%**	**3%**	**4%**	**5%**	**7.5%**	**10%**
1.0	1.9	2.7	3.5	4.3	6.0	7.5

Lastly, the multinomial Logit model we have studied here has assumed no outside good. Our results extend directly to the case with an outside good with the one change being that the market shares in expression (10) need to be interpreted as "comprehensive shares" that are calculated including the outside good's sales.[12] As such, in that case, as with the elasticity of demand in the Cournot model, the level of the non-merging firms' shares could matter if they are related to the outside good's share.

[11] Synergies here are defined as the percentage change in the merging firms' type, i.e., as $[\overline{T}_M - (T_m + T_n)]/(T_m + T_n)$, with $T_m = T_n$ for the case of a symmetric-firm merger.

[12] The numbers reported in Tables 3 and 4 would be higher the greater is the market share of the outside good. For instance, if the market share of the outside good is 20%, the numbers in Tables 3 and 4 have to be multiplied by 1.44 and 1.2, respectively; if the outside good's market share is 50%, the factors are 4 and 2, respectively.

3.3 Whither the Herfindahl Index?

The theoretical results above indicate that, at least in the Cournot and Logit models, it is the merging firms' shares — and, in the Cournot model, the change in the Herfindahl index — rather than the overall level of market concentration that concentration-based merger screens should focus on. How might one then understand why current practice has focused on the market's overall concentration level? Intuitively, the idea behind it seems related to the fact that, in the Cournot model, for example, reducing the number of firms by one has increasingly large price elevation effects the fewer firms are in the market. But, notice that this is a logic that focuses on mergers that harm consumers. Formally, the magnitude of the resulting shortfall in consumer surplus depends on the characteristics of the non-merging outsiders. For example, in the Cournot model, taking the derivative of consumer surplus with respect to the merged firm's post-merger marginal cost, evaluated at the level at which the merger would just be CS-neutral, we obtain:

$$\frac{dCS(Q^*)}{dQ}\frac{dQ}{d\overline{c}_M} = -\frac{Q^*}{|\mathcal{F}| - \sigma(Q^*)},$$

where $\sigma(Q) \equiv -QP''(Q)/P'(Q) < 1$ is the curvature of inverse demand. Hence, at a given pre-merger equilibrium output level Q^*, the shortfall in consumer surplus is the smaller, the larger is the number of firms before the merger, $|\mathcal{F}|$. This also implies that if the antitrust authority's goal is to ensure that the post-merger CS-level is at least a fraction x of the pre-merger level, with x strictly less than (but close to) one, then the required merger-induced efficiencies are decreasing in $|\mathcal{F}|$. The key force driving this is that with fewer rival firms, non-merging firms replace less of any reduction in the merging firms' supply.[13]

In sum, the current focus on the level of the Herfindahl index may be more about limiting excessive consumer harm than about preventing it entirely.

[13] A similar result can be shown in the Logit model. Specifically, if the post-merger type $\overline{T}_M$ falls short by a small fraction, the shortfall in consumer surplus is given by

$$-\frac{dCS(A^*)}{dA}\frac{dA}{d\overline{T}_M}\overline{T}_M = -\frac{\frac{T_M}{A^*}S'\left(\frac{\overline{T}_M}{A^*}\right)}{\frac{\overline{T}_M}{A^*}S'\left(\frac{\overline{T}_M}{A^*}\right) + \sum_{f\notin M}\frac{T_f}{A^*}S'\left(\frac{T_f}{A^*}\right)}$$
$$= -\frac{S^{-1}(s_M)S'\left(S^{-1}(s_M)\right)}{S^{-1}(s_M)S'\left(S^{-1}(s_M)\right) + \sum_{f\notin M}S^{-1}(s_f)S'\left(S^{-1}(s_f)\right)}.$$

Note that the right-hand side depends on the market shares of the non-merging outsiders. Specifically, a mean-preserving spread of the market shares of the non-merging firms reduces $\sum_{f\notin M}\frac{T_f}{A^*}S'\left(\frac{T_f}{A^*}\right)$, and thus makes consumer surplus less responsive to a shortfall in the merger-induced efficiencies, provided the market share of each non-merging firm does not exceed 0.65.

4 Empirical Analysis of Mergers in Brewing

The theoretical results above suggest that the presence of consumer harm from a horizontal merger may be more strongly related to the change in the Herfindahl than to its post-merger level. However, these models are very special, and the results still left some possibility for the level of the Herfindahl to be related to the presence of consumer harm through its relation to aggregate conditions such as the market elasticity of demand in the Cournot model or the outside good share in the Logit model with an outside good. In this section, we take a different tack, by looking empirically at the relationship between the synergy required to prevent consumer harm in various hypothetical mergers in the U.S. brewing industry to the post-merger Herfindahl index and the merger-induced change in the Herfindahl (both naively computed).

We focus on the brewing industry because markets for beer are local, giving us many hypothetical mergers with varying market shares and market conditions, and because prior work by Miller and Weinberg (2017) has estimated a demand system and marginal costs for the major beer brands. We focus on the estimates from Miller and Weinberg's RCNL-1 monthly model, a random-coefficient nested Logit model that is not covered by our analysis in Section 3.2. We use these demand estimates, Miller and Weinberg's derived region/brand-specific marginal costs, and the values of the exogenous determinants of demand in each region in January 2005 (the first month of the Miller and Weinberg estimation sample) to simulate each possible hypothetical merger among the producers in each of Miller and Weinberg's 39 local markets. Given the five firms in their estimation model, this gives 10 possible mergers in each local market, for a total of 390 hypothetical mergers.

For each possible merger and a given specified synergy for the merging firms (which reduces the pre-merger marginal costs of each of the merging firms' products by the same fixed percentage), we compute the pricing equilibrium and resulting consumer welfare. We do this for various possible synergy levels, and identify the synergy level at which the merger is CS-neutral. As well, we calculate the naively-computed post merger Herfindahl and the change in the Herfindahl for that merger, with the shares for this computation including all firms in the market, not just the five firms in the Miller and Weinberg estimation model.[14] We then examine how these two characteristics of mergers are related to the required synergy across our hypothetical mergers.

Figure 1 plots the results. Green circles indicate mergers whose required efficiency gain is 0-5%; yellow indicates those with a required gain between 5% and 10%, blue between 10% and 15%, and red above 15%. Two aspects of the figure are striking. First, whether a merger would require less than a 5% efficiency gain to avoid harming consumers is evidently highly related to the change in the Herfindahl, and almost completely unrelated to the level of the post-merger Herfindahl. Table 3 shows the results of a regression of the required synergy on the post-merger naively-computed Herfindahl and its change, as well

[14] The results we report here use volume shares; the result are very similar using revenue shares.

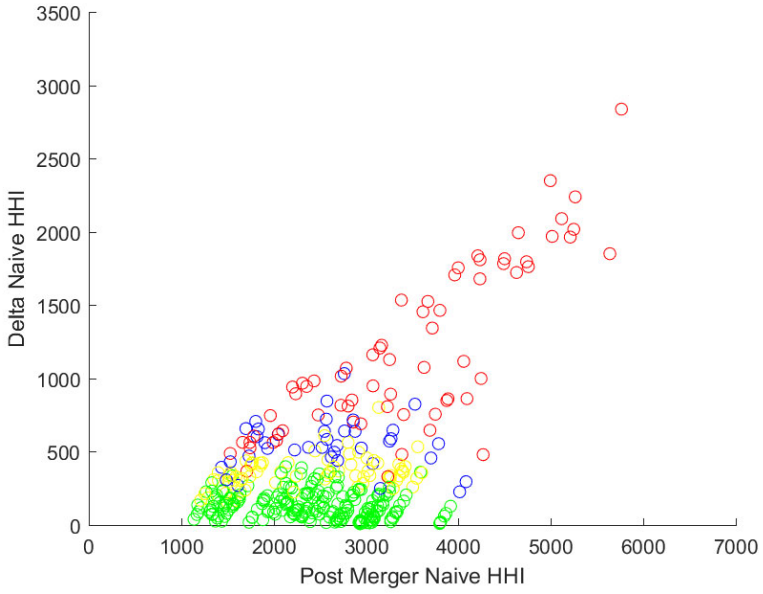

Figure 1: Relationship between the synergy required for a merger to be CS-neutral and the post-merger naively-computed Herfindahl index and its naively computed change [green $< 5\%$; yellow 5-10%, blue 10-15%; red $> 15\%$]

as a constant. As suggested by Figure 1, the R^2 is very high (0.86), and we cannot reject no dependence of the required synergy on the post-merger level of the Herfindahl (the coefficient on H is also very small in magnitude).[15]

Figure 3 focuses in further on the mergers that have a required synergy no greater than 5%. Once again, there appears to be little relationship between the required synergy and the level of the post-merger Herfindahl index, and a fairly strong, though a bit noisier, relationship to the change in the Herfindahl. Table 4 shows the regession results for these 213 mergers. The R^2 is still quite high (0.73), and the results confirm the impressions from Figure 3. In fact, while the level of the Herfindahl is now statistically significant, its sign shows a *negative* relationship between the Herfindahl and the required synergy to avoid consumer harm; in any case, its magnitude is very small.

Second, from the regression in Table 4 we see that the change in the Herfindahl at which a merger with a 5% synergy is CS-neutral is 339, which corresponds to a symmetric merger of firms each having a 13.0% share. With a 3% synergy,

[15] We have also produced plots for those mergers with above vs. below median levels of the market demand elasticity, and with above vs. below median levels of the outside good market share. They all show the same strong effect of ΔH and little effect of the level of the post-merger Herfindahl. The ΔH threshold between green and yellow is somewhat lower for markets with a low elasticity and with a high outside good share.

X_name	beta	se_robust
constant	-0.073793359	0.009736821
Post merger Naive HHI	-2.78396E-07	3.41556E-06
Delta Naive HHI	0.000245653	1.13812E-05
stats_name	print_stats	
n. obs	390	
R^2	0.859160702	

Figure 2: Regression of synergy required for no consumer harm on a constant, the naively-computed post-merger Herfindahl index, and its change.

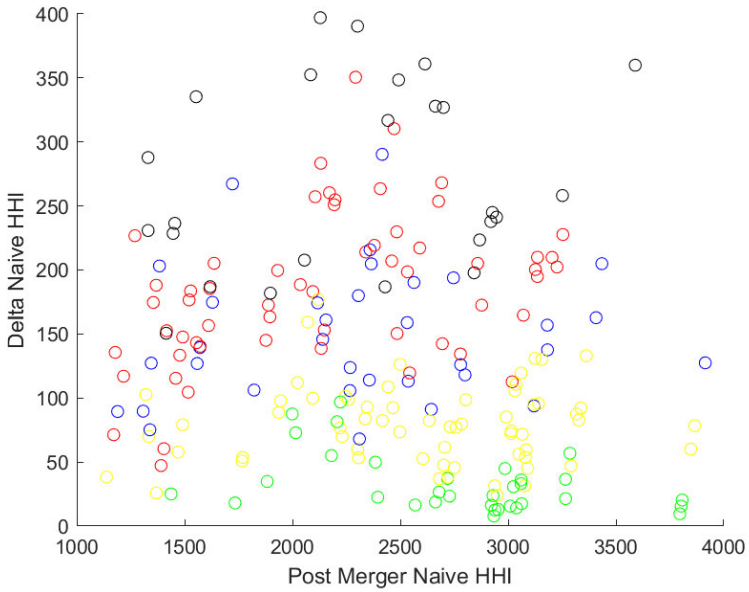

Figure 3: Relationship between the synergy required for a merger to be CS-neutral and the post-merger naively-computed Herfindahl index and its naively computed change, restricted to the 213 mergers with required synergies below 5% [green 0-1%; yellow 1-2%, blue 2-3%; red 3-4%; black 4-5%]

X_name	beta	se_robust
constant	0.015260011	0.00208208
Post merger Naive HHI	-2.8213E-06	6.77343E-07
Delta Naive HHI	0.000116348	5.38648E-06
stats_name	print_stats	
n. obs	213	
R^2	0.727662539	

Figure 4: Regression of synergy required for no consumer harm on a constant, the naively-computed post-merger Herfindahl index, and its change, for the 213 mergers with required synergies below 5%

the level of ΔH at which a merger is CS-neutral would instead be 172, corresponding to two firms with a 9.3% share each, and with a 1% synergy, the level of ΔH at which a merger is CS-neutral would be 89, corresponding to two firms with a 6.7% share each. These thresholds are less stringent than the thresholds arising in both of the models of Section 3 and present a more nuanced picture of the 2010 *Guideline* thresholds. As is evident from Figure 3, a good number of our hypothetical mergers have post-merger Herfinahl levels below 1500 and nonetheless would result in consumer harm with synergies in the 3-5% range. At the same time, the results also indicate that many mergers with post-merger Herfindahl indices above 2500 and with ΔH above 200 would benefit consumers if there were synergies in this range. Both of these errors arise because of the current *Guidelines* use of the level of the post-merger Herfindahl index. Of course, if mergers with a post-merger Herfindahl above 2500 are scrutinized further and potentially allowed, while mergers with a post-merger Herfindahl level below 1500 are simply allowed, this error could result in too lax a policy.

Section 3.3 suggested that the Herfindahl might matter more if we instead looked at the synergy required to have some fixed percentage reduction in consumer welfare. Figure 5 shows a similar plot to Figure 1, but for the synergy required for consumer welfare to decrease by 3% (black indicates negative synergies; i.e., cost increases); there is little evidence, however, of any significant relation to the level of the post-merger Herfindahl, while the change in the Herfindahl evidently remains quite important.

5 Conclusion

In this paper we have explored the use of concentration measures to screen horizontal mergers. Looking both theoretically and empirically, our results suggest that such screens should most likely focus much more on the merger-induced (naively-computed) *change* in the Herfindahl index than on its post-merger level.

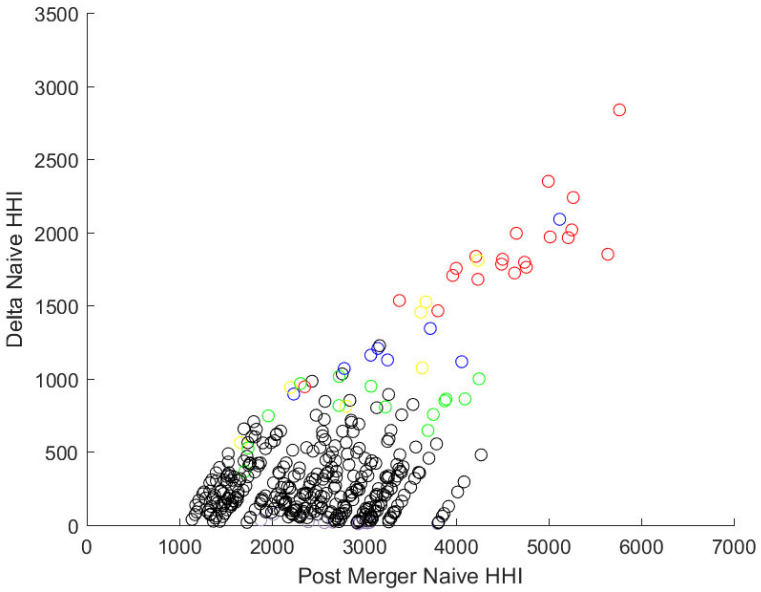

Figure 5: Relationship between the synergy required for a merger to reduce consumer surplus by 3% and the post-merger naively-computed Herfindahl index and its naively computed change [black $< 0\%$; green 0-5%; yellow 5-10%, blue 10-15%; red $> 15\%$]

As such, they suggest screens closer in form to the 1968 *Guidelines* than to the current ones.

In terms of stringency, our conclusions are somewhat less clear: while our theoretical analysis indicated that in both the Cournot and Logit models the thresholds in the current *Guidelines* are almost certainly too lax (unless entry, repositioning, or other factors on average prevent any anti-competitive effects in the typical merger), our empirical analysis of hypothetical beer mergers presented a more nuanced picture of the current 2010 *Guidelines* as there were many mergers with post-merger Herfindahl levels below the current 1500 safe harbor that would lead to consumer harm even with a 5% synergy, but also many mergers with post-merger Herfindahls above 2500 that would benefit consumers. However, to the extent that mergers that fall within safe harbors are simply allowed without further scrutiny, while those that fall into the anti-competitive presumption are scrutinized further and may be allowed based on that further analysis, the concentration screens in the current *Guidelines* may nonetheless result in too lax a policy.

We see three useful directions for further work to refine concentration screens for horizontal mergers. First, further empirical analysis along the lines of that in Section 4 in other markets with different estimated demand and costs would be very useful. Second, more evidence on the synergies arising in horizontal mergers, especially conditional on market structure, would be extremely valuable. Third, continuing work on merger retrospectives is important, especially aimed at learning both the extent to which entry, repositioning, or other factors on average ameliorate unilateral anti-competitive effects, and the extent to which coordinated effects arise that exacerbate them.

At the same time, of course, concentration screens are just one piece of the merger evaluation puzzle, and are only useful when combined with effective in-depth analysis of mergers deemed to raise possible competitive concerns.

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