Quantitative Methods for Evaluating the Unilateral Effects of Mergers*

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December 15, 2020
First Draft: March 17, 2020

Abstract

We describe the quantitative modeling techniques that are used in horizontal merger review for the evaluation of unilateral effects, and discuss how the 2010 Horizontal Merger Guidelines helped legitimize these methods and motivate scholarly research. We cover markets that feature differentiated-products pricing, auctions and negotiations, and homogeneous products, in turn. We also develop connections between quantitative modeling and market concentration screens based on the Herfindahl-Hirschman Index (HHI).

JEL Codes: L13, L40, L41

Keywords: Mergers, Antitrust, Unilateral Effects

*The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the Board research staff or the Board of Governors. We thank David Benson, Breno De Castro Vieira, Joseph Farrell, Evan Gee, Arnd Klein, Alex MacKay, Russell Pittman, Carl Shapiro, Charles Taragin, and Nathan Wilson for helpful comments.

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1 Introduction

In this article, we describe what we view as the state-of-the-art quantitative modeling techniques for horizontal merger review. We discuss how the 2010 Horizontal Merger Guidelines of the U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC) have helped legitimize these methods within the antitrust community and motivate scholarly research. As best we can discern, the notion that formal models could inform merger review emerged from the game-theoretical revolution in industrial organization during the 1980s. Initially, this research was mostly theoretical (e.g., Tirole (1988)), but soon thereafter empirical tools were devised to apply these models to data (e.g., Berry et al. (1995)). The modeling techniques we describe here are the result of an ongoing interplay between current academic research and antitrust practice.

Our particular focus is on models that seek to capture the *unilateral effects* of mergers. We find it helpful to conceptualize unilateral effects as those arising because mergers alter firms' equilibrium strategies in one-shot oligopoly games.[1] As a general matter, competition between firms creates strategic externalities because, by maximizing profit, firms take actions that reduce the profits of rivals. Mergers internalize these externalities by allowing the merging firms to pursue joint profit maximization. In most models, this increases prices, lowers output, and reduces consumer surplus and total welfare, unless the change in strategic incentives is offset by merger efficiencies.[2] Unilateral effects can be contrasted to *coordinated effects*, which involve shifts to or among supracompetitive equilibria in a dynamic game.[3]

Quantitative modeling can play multiple roles in merger review.[4] It can clarify the mechanisms through which the merger might affect market outcomes, and thereby provides an economic rationale for any enforcement action. Models can help inform the types of evidence that should be sought in an investigation, and help determine which matters receive scarce investigational resources. Finally, quantitative modeling can provide a way to predict merger effects, accounting for any countervailing efficiencies. This ability to balance possibly offsetting forces is particularly important in the context of litigation, in helping courts wade through plaintiffs' and defendants' various

[1] For a formal definition of unilateral effects, see Werden (2008).

[2] Mergers can also reduce innovation incentives, though we do not focus on that possibility here. See Federico et al. (2019) for analysis and a useful discussion of the literature.

[3] Recent empirical research has made progress on the quantitative modeling of coordinated effects (e.g., Igami and Sugaya (2019); Miller et al. (2019)).

[4] We focus in this article on model-based methods, which contrast with other empirical work, such as the study of natural experiments, that is not tied to a structural framework.

arguments to decide whether the net effect of a merger is harmful for consumers.[5]

Perhaps ironically, one thing that quantitative modeling does *not* typically accomplish is a precise quantification of merger effects. Models by their nature are simplified representations of the world. Their purpose is to isolate the most important ways that mergers affect economic incentives, and they need not account for secondary and tertiary details. Furthermore, as parametric assumptions are necessary to make predictions, some uncertainty is inevitable. Thus, our view is that modeling should not be expected to provide precise estimates of merger effects, but rather should be used to assess countervailing forces and provide an overall sense of magnitudes.

We come now to the Horizontal Merger Guidelines (hereafter, the "Guidelines") and their role in promoting unilateral effects analysis. The Guidelines were first promulgated in 1968. Major revisions were issued in 1982, 1992, and 2010, with minor revisions in 1984 and 1997.[6] Unilateral effects first appeared in the 1992 version. Reflecting the state of research at the time, the theoretical basis for unilateral effects was sketched, but scant empirical direction was provided. As research and antitrust practice evolved over the 1990s and 2000s, further revision became increasingly necessary. Carl Shapiro, a principle author of the 2010 Guidelines, describes this history as follows:

> The biggest shift in merger enforcement between 1992 and 2010 has been the ascendancy of unilateral effects as the theory of adverse competitive effects most often pursued by the Agencies. Prior to 1992, merger enforcement focused primarily on coordinated effects. In recent years, a sizeable majority of DOJ merger investigations have focused on unilateral effects. Along with this pronounced shift in practice has come considerable new economic learning about unilateral effects. This shift in practice and advance in learning regarding unilateral effects was one of the chief reasons we at the DOJ felt that the time had come to update the Guidelines.[7]

The 2010 Guidelines update and improve the treatment of unilateral effects along multiple dimensions. They explicitly state that the antitrust agencies may rely on quantitative models to inform enforcement decisions, which has in turn helped legitimize modeling in the broader antitrust community. The 2010 Guidelines also provide more

[5] Sometimes multiple models may be used in a single merger review, with each model designed to answer a particular question. At the risk of over-generalization, models designed for internal agency decision-making tend to be more sophisticated (and complicated) than those presented in litigation.

[6] The DOJ and FTC also released a helpful discussion document in 2006, the Commentary on the Horizontal Merger Guidelines (henceforth, the "Commentary").

[7] Shapiro (2010), page 712. The "Agencies" refers to the DOJ and FTC.

complete discussions about the theoretical considerations and empirical evidence that amplify or diminish concerns about unilateral effects, given the specific institutional details of the market in question. Shapiro (2010) describes these changes as part of the continued evolution of the Guidelines "from hedgehog to fox."[8] Further, by accurately characterizing the state of antitrust practice, the 2010 Guidelines have spurred (and continue to spur) research into unilateral effects.

We organize the remainder of this article as follows. We begin with three sections that, in turn, cover differentiated price competition, procurement auctions, and homogeneous products quantity competition. This parallels the material in Section §6 ("Unilateral Effects") of the 2010 Guidelines. In each section, we sketch the most commonly-used theoretical frameworks and quantitative modeling techniques, and discuss the continuing interplay of research and antitrust practice. We hope the material is useful for practitioners seeking to apply quantitative modeling in merger review, and to academics seeking to make practical contributions to antitrust economics.

We then connect the game-theoretical analysis of unilateral effects to market concentration screens based on the Herfindahl-Hirschman Index (HHI). Our objective is to correct any misconception that market concentration screens are not theoretically justified by unilateral effects models. We draw on recent research and generate numerical results to provide a visualization. The 2010 Guidelines state that a merger will be presumed anticompetitive if the post-merger HHI exceeds 2,500 and the change in HHI (ΔHHI) exceeds 200.[9] Our analysis suggests that a simple tweak might better align merger review with economic theory: a presumption that applies if the post-merger HHI exceeds 2,500 or the ΔHHI exceeds 200. The first of these conditions would screen for coordinated effects and concerns about harm to potential competition, and the second condition would screen for unilateral effects.[10]

[8]We use the "from hedgehog to fox" description of merger review throughout this article. This follows Shapiro (2010), which states (pages 703-704) that:

> "Isaiah Berlin's famous allusion to the different ways in which the Hedgehog and the Fox view the world is a useful model for how to think about the evolution of the Merger Guidelines. The hedgehog knows one big thing. Likewise, the 1968 Guidelines were based on one big idea: horizontal mergers that increase market concentration inherently are likely to lessen competition.... [T]he fox knows many things. Likewise, merger enforcement in recent years has become increasingly eclectic, reflecting the enormous diversity of industries in which the Agencies review mergers and the improved economic toolkit available."

[9]The HHI equals the sum of squared market shares, with the shares being measured on a scale from zero to 100. The ΔHHI is calculated as twice the product of the merging firms' market shares.

[10]We are not the first to propose that a screen based solely on the ΔHHI would better align with unilateral effects theory. See, for example, Nocke and Whinston (2020), or the other articles cited

In the conclusion, we relate the modeling frameworks and results developed herein to two other articles in this issue (Carlton and Israel (2020); Valletti and Zenger (2020)) and discuss briefly how courts have interpreted evidence generated from quantitative modeling. In the discussions that follow, we draw upon an incredibly rich literature that has been produced over multiple decades by academics, agency economists, and antitrust consultants alike. We have found it impossible to do justice to all of the relevant contributions, and we offer our apologies to any whose research has been omitted. Complementary literature reviews can be found in other articles (e.g., Willig (1991); Werden (2008); Shapiro (2010)).

2 Differentiated Products Pricing

The area in which empirical methods for horizontal merger analysis have seen the most work is in cases of differentiated products in Bertrand oligopoly settings. Many of these approaches have their roots in the 1992 Guidelines and contemporaneous academic research, but their use has become more widespread since the release of the 2010 Guidelines.

2.1 Analytical Framework

The typical analysis emerges from the Bertrand model of oligopoly competition. Let each firm set prices that maximize its profit, conditional on the prices of its competitors. Firms face the standard trade-off that higher prices improve the profit margin per unit but reduce the quantity demanded by consumers. These effects balance if the following first-order condition is satisfied:

$$p_i + \left[\frac{\partial q_i(p)}{\partial p_i}^T\right]^{-1} q_i(p) = mc_i(q_i), \tag{1}$$

where p_i, q_i, and $mc_i(\cdot)$ are vectors for firm i's prices, quantities, and marginal costs, respectively, and p is a vector of all firms' prices.[11] We assume products are substitutes, i.e., that $\partial q_j/\partial p_k > 0$ for any products $j \neq k$. The left-hand side of the equation is marginal revenue; thus, profit maximization in this setting requires that marginal revenue equals marginal cost. For simplicity, and because our experience suggests

herein.

[11] Throughout this article, we use the superscript T to refer to the vector/matrix transpose operation.

that marginal costs tend to be approximately constant over the relevant range with differentiated products, we assume $mc_i(q_i) = mc_i$ hereafter.[12]

In this setting, if any firm lowers its prices, it gains some consumers that otherwise would have purchased from competitors. These pricing externalities—the consequences of competition—push equilibrium prices toward marginal cost, benefiting consumers and increasing welfare. Mergers internalize the pricing externalities and create profit incentives for firms to raise prices. Absent countervailing efficiencies, this results in adverse consequences for consumers and welfare.

Formally, if a merger occurs between firms j and k, then post-merger first order conditions for the products initially owned by j take the form:

$$p_j + \left[\frac{\partial q_j(p)}{\partial p_j}^T\right]^{-1} q_j(p) = mc_j - \left[\frac{\partial q_j(p)^T}{\partial p_j}\right]^{-1} \left(\frac{\partial q_k(p)^T}{\partial p_j}\right) (p_k - mc_k). \qquad (2)$$

Comparing to the equation (1), the left-hand-side is identical, but the right-hand-side is greater due to the addition of a new term that represents the merger effect ($\partial q_j/\partial p_j < 0$ with downward-sloping demand). There are two equivalent intuitions. The first is that a merging firm may find higher prices to be profitable post-merger because some of the lost sales are recaptured by the merging partner. The second is that the merger creates an opportunity cost because if a merging firm increases its quantity (e.g., by lowering price), it cannibalizes some profit that otherwise would have been obtained by the merging partner. This latter intuition is bolstered by the fact that the new term enters the first order conditions in the same way as marginal cost.

The analysis to this point is straight-forward and follows from a simple game-theoretical analysis of pricing incentives. Much of the guiding research was conducted in the 1980s and was known at the time the 1992 Guidelines were drafted.[13] Thus it is that the 1992 and 2010 Guidelines use virtually identical language to describe how mergers affect pricing incentives in differentiated products markets. The 1992 Guidelines state:

> A merger between firms in a market for differentiated products may diminish competition by enabling the merged firm to profit by unilaterally raising the price of one or both products above the premerger level. Some of the

[12] See also Werden and Froeb (1998), page 532: "A stylized fact of US industry is that marginal costs are typically constant...." We revisit this subject in our discussion of homogeneous products (Section 4).

[13] Robert Willig, a primary author of the 1992 Guidelines, provides a description of the modeling framework in Willig (1991).

> sales loss due to the price rise merely will be diverted to the product of the merger partner and, depending on relative margins, capturing such sales loss through merger may make the price increase profitable even though it would not have been profitable premerger.[14]

Next, the 2010 Guidelines:

> A merger between firms selling differentiated products may diminish competition by enabling the merged firm to profit by unilaterally raising the price of one or both products above the pre-merger level. Some of the sales lost due to the price rise will merely be diverted to the product of the merger partner and, depending on relative margins, capturing such sales through merger may make the price increase profitable even though it would not have been profitable prior to the merger.[15]

At this point, the 1992 and 2010 Guidelines diverge, with the former focusing on the conditions under which market shares correlate with the magnitude of unilateral effects, and the latter providing an in-depth discussion about how the opportunity costs created by the merger can be quantified and translated into price effects in specific market settings. In doing so, the 2010 Guidelines draw on knowledge embedded in the antitrust agencies, accumulated from decades of merger review, and also on insights developed in the academic literature. The 2010 Guidelines, in turn, have spurred academic research that extends and improves the modeling of unilateral effects in differentiated products markets in various and useful ways.

2.2 Merger Simulation

A two-step procedure for merger quantification—merger simulation—emerged in the academic literature shortly after the release of the 1992 Guidelines (e.g, Berry and Pakes (1993); Hausman et al. (1994); Werden and Froeb (1994)). To illustrate, start again with equation (1) and stack the first order conditions of each firm. This yields a formulation of Bertrand equilibrium that commonly appears in the empirical industrial organization literature (e.g., Nevo (2001)):

$$p + \left[\Omega \circ \frac{\partial q(p)}{\partial p}^T\right]^{-1} q(p) = mc, \tag{3}$$

[14] 1992 Guidelines, §2.21.
[15] 2010 Guidelines, §6.1.

where the (j, k) element of the symmetric "ownership matrix," Ω, equals 1 if products j and k are owned by the same firm, and zero otherwise, and where the $\circ$ symbol refers to element-by-element multiplication. Passive ownership and partial acquisitions can be modeled with elements of the ownership matrix between zero and one.[16] This provides a system of equations that can be used both for inference about the pre-merger equilibrium (the "imputation step") and for prediction about merger effects (the "simulation step").

In academic research, the imputation step typically involves demand estimation to obtain the derivatives, $\partial q(p)/\partial p$. With prices and quantities, and letting Ω reflect pre-merger product ownership, marginal cost then is identified from equation (3). In merger review, the direction of inference can be reversed: data on marginal costs and diversion are used to recover the demand derivatives, and this in turn allows demand to be calibrated.[17] The antitrust agencies often rely on simple demand functional forms, such as the logit (e.g., Werden and Froeb (1994, 2002)), the Almost Ideal Demand System (e.g., Epstein and Rubinfeld (2001)), or linear demands, rather than the more sophisticated random-coefficients logit demand system (Berry et al. (1995)) that is popular in academic research. This difference reflects the resources available. In merger review, the time and data necessary for sophisticated demand estimation often are unavailable, but margins and diversion may be obtained from confidential documents.[18]

In the simulation step, Ω is adjusted to account for post-merger product ownership. This incorporates additional terms into the merging firms' first order conditions, just as in equation (2) and with the same intuitions. Post-merger prices that solve the new system of equations can be computed numerically. Because the merger moves prices away from the pre-merger equilibrium, some parametric assumptions on demand are required. As is well known, demand systems with more convex curvature tend to generate greater pass-through and also larger merger effects (Crooke et al. (1999); Froeb et al. (2005); Miller et al. (2016)). This sensitivity does not appear to affect the *direction* of price effects because, for example, demand systems with more curvature also generate greater pass-through of cost reductions. We develop the connection between

[16] The 2010 Guidelines, §13, address partial acquisitions.

[17] We define diversion explicitly in the next subsection.

[18] See Miller et al. (2016) for details on the calibration of the linear, log-linear, almost ideal, and logit demand systems. Caradonna et al. (2020) show how to partially calibrate logit demand with (only) market shares; this is sufficient to obtain the percentage change in markups caused by a merger without efficiencies. As an extension, the academic literature has examined how merger simulation responds to the presence of consumer search costs or switching costs (e.g., Allen et al. (2013); MacKay and Remer (2019)). To our knowledge, these refinements have yet to be applied in investigations.

pass-through and merger price effects more explicitly below.

Just as structural modeling gained traction in empirical industrial organization, simulation became more prevalent in merger review. In *Maybelline/Cosmair* (1996), the DOJ estimated demand for mascara from available scanner data and then performed a merger simulation that indicated price effects would not be substantial.[19] Similarly, the FTC estimated demand in *General Mills/Pillsbury* (2001) and did a merger simulation.[20] During the *H&R Block/TaxACT* (2011) trial, the DOJ presented a Bertrand merger simulation with linear demand.[21] More recently, the antitrust agencies have relied on more sophisticated simulations, approaching the structures commonly seen in the scholarly literature, where complex demand and supply functions are the norm. In *AT&T/DirecTV* (2015), experts working on behalf of the FCC and those working on behalf of the merging firms both constructed simulation models with nested logit demands estimated using detailed, geographically disaggregated data.[22] Based in part of these results, the FCC decided to approve the transaction. During the litigation of *Aetna/Humana* (2016), the DOJ's expert also used a merger simulation with nested logit demand.[23]

2.3 Upward Pricing Pressure

An interpretation of the first order conditions in equation (2) is that the merger creates *upward pricing pressure* by imposing opportunity costs on the merging firms (Farrell and Shapiro (2010)).[24] For simplicity, consider the case of single-product firms.[25] Then the opportunity cost—the magnitude of upward pricing pressure or "UPP"—imposed by the merger on merging firm j is given by

$$UPP_j = \underbrace{d_{jk}}_{\text{Diversion}} \times \underbrace{(p_k - mc_k)}_{\text{Markup}}. \tag{4}$$

[19] See 2006 Commentary, §2.

[20] See 2006 Commentary, §2. The commentary also mentions Bertrand merger simulation in two other DOJ cases: *Interstate Bakeries/Continental* (1995) and *Vail Resorts/Ralston Resorts* (1997). In the latter instance, demand was measured using survey data.

[21] See the Memorandum Opinion at page 76, describing testimony by Frederick Warren-Boulton.

[22] See Appendix C to the FCC Memorandum Opinion and Order.

[23] See the demonstrative exhibit used by Aviv Nevo, at slides 63-66, available at `https://www.justice.gov/atr/page/file/918706/download`.

[24] The upward pricing pressure approach of Farrell and Shapiro (2010) draws on preceding research on merger price effects (e.g., Werden (1996); O'Brien and Salop (2000)) that we review later.

[25] For the case of multi-product firms, see equation (8).

The first term in this formula, $d_{jk} \equiv (\partial q_k/\partial p_j)/(\partial q_j/\partial p_j)$, is the *diversion ratio*. It provides the fraction of sales lost by firm j due to an increase in its price that would be recaptured by firm k.[26] Economic theory indicates that this recapture matters for post-merger pricing incentives only to the extent that profit is earned on the diverted sales. Thus, the relevant notion of UPP for firm j is constructed as the multiplicative product of diversion from j to k and the markup of firm k. Neither diversion nor markups in isolation are sufficient to capture the pricing incentives of the merged firm.

The UPP framework allows for a micro-founded analysis of post-merger pricing incentives if reasonable estimates of diversion and markups can be obtained for the merging firms. In practice, UPP often is converted to an index in order to provide a unit-free measure of the merger's impact on pricing incentives. Let the gross upward pricing pressure index ("GUPPI") be given by

$$GUPPI_j = \underbrace{d_{jk}}_{\text{Diversion}} \times \underbrace{m_k}_{\text{Margin}} \times \underbrace{\frac{p_k}{p_j}}_{\text{Relative Prices}} \tag{5}$$

where $m_k = (p_k - mc_k)/p_k$ is the price-cost margin of firm k.[27] The 2010 Guidelines describe the GUPPI as providing an important diagnostic for unilateral effects in markets with differentiated products. In doing so, it first defines the *value of diverted sales* in terms that track precisely equation (5):

> The value of sales diverted to a product is equal to the number of units diverted to that product multiplied by the margin between price and incremental cost on that product.... For the this purpose, the value of diverted sales is measured in proportion to the reduction in unit sales resulting from the price increase. Those lost revenues equal the reduction in the number of units sold of that product multiplied by that product's price.[28]

The Guidelines then state:

> The Agencies rely much more on the value of diverted sales than on the

[26] As best we can discern, the term "diversion ratio" was coined by Carl Shapiro (Shapiro (1995, 1996)), though the concept dates at least to Willig (1991). Empirical articles in industrial organization continue to focus more on demand elasticities; however, see Conlon and Mortimer (2019) for a detailed discussion of how diversion can be estimated from data on prices and shares.

[27] For more on the development of upward pricing pressure indices, see Moresi (2010) and the other contributions cited in footnote 90 of Farrell and Shapiro (2010).

[28] 2010 Guidelines, §6.1.

level of the HHI for diagnosing unilateral price effects in markets with differentiated products.[29]

An important insight that emerges from UPP analysis is that the effect of a merger on unilateral pricing incentives depends on two main objects: diversion and margins.[30] Firms typically have a strong incentive to understand both their costs and the substitution patterns of their consumers, so information on these objects often becomes available to antitrust agencies during the course of merger investigations. The 2010 Guidelines specifically mention documentary and testimonial evidence, "win/loss" reports, reports on consumer switching, and customer surveys as among the evidence that may support inferences about diversion. The Guidelines provide less guidance on margins but, in our experience, reasonable estimates often can be culled from documents, testimony, and normal-course pricing analyses. Accounting data also can be informative, especially if fixed and variable costs can be distinguished.[31]

First Order Approximation and Cost Pass-Through

Farrell and Shapiro (2010) introduce UPP as a simple measure of post-merger pricing incentives but caution against interpreting it as a predictor of actual price changes.[32] Yet they also suggest a methodology by which UPP analysis might provide a price prediction: because UPP represents an opportunity cost, and enters the post-merger first order conditions in the same manner as marginal cost, the multiplicative product of UPP and cost pass-through might be informative of unilateral price effects.

This idea is formalized in the subsequent research of Jaffe and Weyl (2013). In deriving the main result, it is convenient to rewrite the pre-merger first order conditions of equation (1) as follows:

$$f_i(p) \equiv -\left(\frac{\partial q_i(p)}{\partial p_i}^T\right)^{-1} q_i(p) - (p_i - mc_i) = 0. \tag{6}$$

[29] 2010 Guidelines, §6.1. Notably, the Guidelines do not state that the Agencies rely on UPP-style analysis more than on the *change* in HHI for diagnosing unilateral effects. As we develop in Section 5, the change in HHI often can be quite informative of unilateral effects in differentiated-products markets.

[30] Mergers can also affect product quality or production costs, which matter for unilateral pricing incentives (Section 2.4). A host of other possibilities exist, but are beyond the scope of this article.

[31] The 2010 Guidelines at §4.1.3 state that "The Agencies often estimate incremental costs, for example, using merging parties' documents or data the merging parties use to make business decisions." Fisher and McGowan (1983) discuss some ways that accounting data can be misleading.

[32] Referring to UPP and concentration analysis, Farrell and Shapiro (2010, page 3) state that "neither approach purports to quantify the likely equilibrium effect (e.g., the price change) of the merger...."

We first develop a formulation of pre-merger pass-through. Stack the first order conditions of each firm, $f(p) = [f_1(p)', f_2(p)', \dots]'$, and consider a vector of taxes, t, such that the post-tax equilibrium is characterized by

$$f(p) + t = 0.$$

Then, by the implicit function theorem,

$$\frac{\partial p}{\partial t}\frac{\partial f(p)}{\partial p} = -I,$$

and pre-merger pass-through is given by

$$\rho \equiv \frac{\partial p}{\partial t} = -\left[\frac{\partial f(p)}{\partial p}\right]^{-1}\Bigg|_{p=p^0}, \tag{7}$$

where p^0 is the vector of prices in the pre-merger equilibrium. As the function $f(p)$ depends on the first derivatives of demand, pass-through depends on both the first and second derivatives of demand (the demand elasticities and curvatures, respectively).

Returning to the effect of the merger between firms j and k, the post-merger first order conditions of any firm i can be expressed as

$$h_i(p) = f_i(p) + g_i(p),$$

where $g_i(p) = 0$ if $i \neq j, k$, and if $i = j$ (symmetrically, if $i = k$) then

$$g_j(p) = -\left[\frac{\partial q_j(p)^T}{\partial p_j}\right]^{-1}\left(\frac{\partial q_k(p)^T}{\partial p_j}\right)(p_k - mc_k). \tag{8}$$

Here $g_j(p)$ and $g_k(p)$ represent the multi-product formulations of UPP if evaluated at pre-merger Bertrand prices. Jaffe and Weyl prove that, to a first order approximation, the vector of merger price effects is

$$\Delta p = -\left(\frac{\partial h(p)}{\partial p}\right)^{-1}\Bigg|_{p=p^0} g(p^0), \tag{9}$$

where $h(p)$ and $g(p)$ again stack the firm-specific vectors. Thus, a price prediction can be obtained by multiplying UPP by pass-through. However, if one is being precise, the

relevant notion of pass-through is not the pre-merger cost pass-through matrix given in equation (7). Rather, observing that the expression contains the Jacobian of $h(p)$ rather than the Jacobian of $f(p)$, the expression uses post-merger pass-through evaluated at pre-merger prices; Jaffe and Weyl refer to this matrix as *merger pass-through*.

The methodology of first order approximation can be interpreted as substituting pass-through for the parametric assumptions common in merger simulation models. Adding to the theoretical appeal is that the objects within the price prediction of equation (9)—pass-through and UPP—are evaluated at pre-merger prices and thus conceptually should be possible to estimate from data. Reduced-form regressions of price on marginal cost can obtain cost pass-through. With known demand elasticities, Slutsky symmetry, and a horizontality assumption, this can allow demand curvatures to be obtained, and merger pass-through then can be calculated. Miller et al. (2016) provide Monte Carlo evidence demonstrating that the procedure is quite accurate in predicting merger price effects under a variety of different demand systems.

But how often are reliable estimates of pass-through available in practice? The results of Jaffe and Weyl (2013), along with those of a related article (Weyl and Fabinger (2013)), have motivated a small renaissance in the empirical literature on pass-through estimation and incidence.[33] Our reading of that literature makes us somewhat pessimistic about the exact application of equation (9) in merger review. Consider the case of a three-firm oligopoly. The reduced-form regression equations typically would take the form

$$\begin{bmatrix} p_{1t} \\ p_{2t} \\ p_{3t} \end{bmatrix} = \begin{bmatrix} \rho_{11} & \rho_{12} & \rho_{13} \\ \rho_{21} & \rho_{22} & \rho_{23} \\ \rho_{31} & \rho_{32} & \rho_{33} \end{bmatrix} \begin{bmatrix} c_{1t} \\ c_{2t} \\ c_{3t} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \end{bmatrix},$$

where c_{it} is some cost-shifter (in dollars per unit sold) associated with firm i and period t, and ϵ_{it} is a reduced-form error term. Because firms producing similar goods tend to have similar production technologies, often there is insufficient empirical variation to separately identify the nine pass-through parameters—the cost terms are too collinear. More frequently, a notion of market pass-through can be estimated based on common cost shocks (e.g., defining market pass-through as $\rho_1^M \equiv \rho_{11} + \rho_{13} + \rho_{13}$).[34] Although market pass-through informs many policy questions, it falls short of the merger pass-

[33] See also Miklos-Thal and Shaffer (Miklos-Thal and Shaffer).

[34] We experienced this first-hand while attempting to estimate pass-through in the cement industry (Miller et al. (2014)). For an exception that may prove the rule, see Muehlegger and Sweeney (2019). MacKay et al. (2014) provide a formal treatment of econometric bias in pass-through regressions.

through matrix needed for the exact application of equation (9).[35]

There are few actual examples of first order approximation being used in a merger investigation or litigation. In the trial for *General Electric/Electrolux* (2015), the expert testifying on behalf of the DOJ used calibrated pass-through rates implied by several different demand systems in order to construct price predictions.[36] This can be a sensible approach when pass-through estimates are unavailable.

UPP as a Predictor of Merger Price Effects

Miller et al. (2017) suggest that the value of UPP itself provides a good approximation for merger price effects. In light of equation (9), this amounts to an argument that using the identity matrix to proxy for merger pass-through may sacrifice little predictive accuracy. Consider a simple numerical example with three symmetric firms. Consumers select between the firms and an outside good in accordance with a logit demand system. Each firm has a margin of 0.50 and a 30% market share. With a merger between the first two firms, equation (9) becomes

$$\begin{bmatrix} 0.204 \\ 0.204 \\ 0.052 \end{bmatrix} = \begin{bmatrix} 0.771 & 0.180 & 0.297 \\ 0.180 & 0.771 & 0.297 \\ 0.122 & 0.122 & 0.776 \end{bmatrix} \begin{bmatrix} .214 \\ .214 \\ 0 \end{bmatrix}.$$

The value of UPP (0.214) nearly equals the first order approximation (0.204) for the merging firms. This happens because the diagonal elements of the merger pass-through matrix are somewhat below one, whereas the off-diagonal elements are positive. Thus, replacing merger pass-through with an identity matrix overstates some effects and understates others; the balance is that UPP is close to the first order approximation. The same countervailing biases arise in many of the differentiated-products demand systems used in industrial organization, though see Miller et al. (2017) for exceptions.

We conduct a short Monte Carlo exercise to provide a visualization. We take random draws on a market with four firms and an outside good. Demand is logit. Each market

[35] Another concern is developed in the Conlon and Rao (2020) study of the distilled spirits market. There most prices end in 99 cents (e.g., $9.99), and price changes predominately occur in one dollar increments (e.g., $9.99 to $10.99). A retailer operating under these constraints might not raise price at all in response to small cost increases but, in the event that a price rise is warranted, the magnitude of the price increase is likely to far exceed that of the cost increase. This can produce pass-through estimates that are implausibly small or implausibly large, depending on the sample.

[36] See the slides used by Michael Whinston as part of his testimony, at page 59, available at `https://www.justice.gov/atr/file/ge-px02015/download`. The merger was abandoned before the trial concluded.

is calibrated using (1) a random assignment of market shares and (2) a margin for the fourth firm that is drawn from a uniform distribution over [0.25,0.75]. Prices are normalized to one. Consider a merger between the first two firms. We calculate UPP and also compute the "true" price effect with merger simulation.[37] Figure 1 summarizes the results. As shown, the dots cluster around the 45°-line, indicating that UPP and the price increases implied by merger simulation are quite similar.

[Figure 1 about here.]

As part of the investigation into the proposed *Reynolds American/Lorillard* (2015) merger, the FTC used UPP to predict price effects, prior to negotiating a divestiture. The analysis is described in Hanner et al. (2016).[38] On the other hand, in our experience, economists engaged in merger review sometimes propose multiplying UPP by 0.50 to obtain a price prediction, with the rationale that this is the pass-through of a monopolist with linear demand. This risks understating price increases for two reasons: First, it ignores the equilibrium feedback effects that increase pass-through in oligopoly models. Second, if demand is convex then pass-through can be much higher than with linear demands, all else equal. Thus it is that the Miller et al. (2017) results indicate that UPP approximates merger price effects reasonably well for linear demands, and provides conservative price predictions if demand is Almost Ideal or log-linear.

2.4 Merger Efficiencies with Differentiated Products

Some mergers make the firms involved more efficient. With sufficiently large gains, consumers can benefit from the merger despite a loss of competition. This trade-off can be accounted for with UPP-style analyses or merger simulation. We focus here on UPP because simulation is more widely understood. Efficiencies typically take the form of marginal cost reductions or quality improvements, and we address each in turn. We also discuss quality-adjusted prices in the context of quality efficiencies.

Because UPP enters the post-merger first order conditions as an adverse (opportunity) cost shock, a cost reduction of the same magnitude "cancels out" UPP such that

[37] The exercise is similar in spirit to that of Miller et al. (2017), which also considers linear demand, the Almost Ideal Demand System, and log-linear demand.

[38] Although it predates the formal development of UPP in the economics literature, the analysis presented by the FTC in *Swedish Match/National Tobacco* (2000) also included similar calculations. See the FTC Proposed Findings of Fact at pages 125-126, which describe testimony by John Simpson, available at `https://www.ftc.gov/sites/default/files/documents/cases/2000/06/swedishmatchpublic.pdf`.

the post-merger first order condition is satisfied at the pre-merger price. Thus, in the case of a single-product firm, *net* UPP exists if and only if

$$d_{jk} \times (p_k - mc_k) > c_j^0 - c_j^1, \tag{10}$$

where c_j^0 and c_j^1 are pre-merger and post-merger costs, respectively. Equivalently, letting $\dot{c}_j \equiv (c_j^0 - c_j^1)/c_j^0$ be the percentage change in costs, and converting UPP to an index, net upward pricing pressure exists if and only if

$$d_{jk} m_k \frac{p_k}{p_j} > \dot{c}_j (1 - m_j) \tag{11}$$

Equations (10) and (11) provide simple diagnostic formulas that can help identify how likely it is that a merger would increase price. Using this type of analysis, the DOJ presented evidence in *General Electric/Electrolux* (2015) that the efficiencies the merging firms claimed were not sufficiently large to overcome positive UPP.[39]

There is a shortcoming of this approach, however. Because the incentive of one merging firm (firm A) to raise price depends on the markup of its merging partner (firm B), if the costs of firm B decrease then the upward pricing pressure created for firm A is amplified. To capture this cross-firm effect, it is necessary to consider the firms' first order conditions simultaneously (Werden (1996)). Prices increase if, for both merging firms, the "compensating marginal cost reduction" (CMCR) is greater than the actual cost reduction:

$$\hat{c}_j \equiv \frac{m_j d_{jk} d_{kj} + m_k d_{kj} p_k / p_j}{(1 - m_j)(1 - d_{jk} d_{kj})} > \dot{c}_j. \tag{12}$$

The results of UPP and CMCR analysis usually align, but in close cases or if greater precision is desired, then the CMCR is more appropriate.[40] In the staff report issued for the proposed *AT&T/T-Mobile* (2011) merger, the FCC provided both UPP and CMCR calculations to show that efficiencies would have to be quite large in order to result in no incentives to raise price.[41]

[39] See the demonstrative exhibit used by Michael Whinston at page 57, available at `https://www.justice.gov/atr/file/ge-px02015/download`.

[40] Equation (12) applies to asymmetric single-product firms. With symmetry, a simplification yields $\hat{c}_j = (m/(1-m))(d/(1-d))$. See Werden (1996) for the case of multi-product firms. Nocke and Whinston (2020) provide an analogous equation that depends only on the market shares of the merging firms, for the specific case of logit demand. Dutra and Sabarwal (2019) provide an adjustment to UPP that may improve accuracy in the presence of cost efficiencies.

[41] See the economic appendix to the Staff Report at pages C-9 to C-10, available at `https://docs.fcc.`

We turn now to quality efficiencies. A UPP-style analysis can be conducted under the assumption that demand can be expressed in terms of quality-adjusted prices, $H_j = v_j - p_j$, where v_j is consumers' willingness-to-pay. This assumption is quite strong. However, with it in place, a merger harms consumers if it causes quality-adjusted prices to increase. Let the pre- and post-merger qualities be v_j^0 and v_j^1, respectively. Then upward pressure exists on quality-adjusted prices if and only if

$$d_{jk} m_k \frac{p_k}{p_j} > \frac{v_j^1 - v_j^0}{p_j}. \tag{13}$$

which again provides a simple diagnostic formula (Willig (2011)).[42]

Serious challenges can arise in obtaining the right-hand side of the inequality. To illustrate the difficulties, consider the case of logit demand. The (transformed) quantity-demanded of product j takes the form:

$$\tilde{q}_j = x_j'\beta - \alpha p_j + \xi_j$$

where x_j is a vector of product characteristics, ξ_j represents unobserved quality, and (β, α) are structural preference parameters. If the merger induces changes in the characteristics, $\Delta x_j \equiv x_j^1 - x_j^0$, then we have $v_j^1 - v_j^0 = \Delta x_j'\beta/\alpha$. Thus, it is necessary to know the change in characteristics (Δx), the responsiveness of demand to characteristics (β), and the responsiveness of demand to price (α). Academic studies in industrial organization often obtain these objects with estimation—see especially Fan (2013), which endogenizes post-merger product characteristics—but, in merger review, data limitations often make it difficult to estimate β.[43] Further, it can be difficult to know Δx, because gun-jumping rules prohibit coordinated planning prior to merger consummation, and because the merger itself can affect firms' incentives to provide quality.

If consumers differ in the value they place on quality then demand cannot be expressed in terms of quality-adjusted prices, and equation (13) does not obtain. Intuition suggests that a merger that increases both quality and prices is likely to benefit

gov/public/attachments/DA-11-1955A2.pdf. The transaction was subsequently abandoned. Pittman and Li (2013) analyze the literature on the economics of density in mobile telephony, and conclude that large efficiencies probably were implausible.

[42] An adjustment allows for cost and quality efficiencies to be evaluated together. Similarly, Nocke and Whinston (2020) provide the critical *type efficiency*—a nonlinear combination of quality and marginal cost improvements—necessary to exactly counterbalance adverse unilateral effects with logit demand. The critical type efficiency depends only on the market shares of the merging firms.

[43] Notably, the responsiveness of demand to characteristics (β) differs from the responsiveness of demand to price (α) because it cannot be inferred from a price-cost margin.

some consumers and harm others. We suspect that analyses based on quality-adjusted prices (in a misspecified model) are informative of the net effects, though this could be usefully examined in future research.[44] More generally, research into methods for the evaluation of quality efficiencies that are theoretically satisfactory and empirically tractable could have substantial value.

3 Auctions and Procurement

Compared to the amount of discussion devoted to Bertrand analysis, the Guidelines spend far less time on auctions. They are only mentioned in footnote 21 of the 1992 Guidelines and are covered in a single page in the 2010 Guidelines. This disparity in emphasis may either be a cause or a symptom of the fact that there are fewer analytical tools aimed at antitrust practitioners wishing to study auction settings. However, there have been some recent developments, likely due in part to the general increasing use of structural modeling and merger simulations since the release of the 2010 Guidelines.

The antitrust agencies tend to rely on auction models for business-to-business markets, and especially in procurement settings when firms issue "requests for proposal" (RFPs). A number of different mechanisms can be used to convert RFP responses into prices or contract terms. For example, the buyer might specify the way in which prices are determined *ex ante*, conduct an informal auction by repeatedly asking bidders to improve their offers, or negotiate with individual suppliers.

3.1 Analytical Framework

A common point of emphasis in examining mergers with auctions is how often the merging firms bid against each other, particularly when they are customers' first- and second-most preferred choices. In an RFP setting, the buyer typically plays suppliers off one other, which resembles a descending price auction. Antitrust economists often model this using second-price or second-score auctions, which elicit strategically equivalent bidding behavior. A helpful baseline framework appears in Miller (2014, 2017), which examines a second-score auction among heterogeneous suppliers of a differentiated product. Waehrer and Perry (2003) examine a similar model in which firms have

[44] Because a more rigorous balancing requires an understanding of consumer heterogeneity, the random coefficients logit model of Berry et al. (1995) seems to have relatively more value for merger review when quality efficiencies are involved.

different costs and capacities for delivering a homogeneous product.

Assume that a consumer i is soliciting bids from a series of suppliers indexed by j, such that the payoff from supplier j is $u_{ij} = v_{ij} - p_j$, where v_{ij} is the gross value of the supplier's product to customer i, and p_j is the price paid. Define the incremental cost, c_j, as the cost that is incurred by the supplier in the event that it is selected. Each supplier observes its own value and incremental cost, but not those of competitors.[45] Price is determined by a second-score auction, where the buyer purchases from the supplier whose bid gives the highest payoff, but the price is such that the realized payoff is equal to that offered by the second-best bid. Given this auction mechanism, it is a weakly dominant strategy for each firm to set its bid equal to its incremental cost. Thus, if supplier j wins the auction we have that

$$p_j = v_{ij} - \max_{l \neq j} \{v_{il} - c_l\}. \tag{14}$$

In equilibrium, the buyer's payoff is equal to the surplus generated by the runner-up product (that is, $\max_{l \neq j}\{v_{il} - c_l\}$ if j is the winning product), while the winning supplier earns the incremental surplus it generates beyond its closest competitor ($v_{ij} - c_j - \max_{l \neq j}\{v_{il} - c_l\}$).

In this setting, price is determined by how narrow the gap is between the surplus generated by the buyer's most and second-most preferred suppliers. Therefore, insofar as a merger alters that relationship, it can cause prices to rise. Specifically, suppose that suppliers j and k merge. Then, if supplier j wins the auction we have that

$$p_j = v_{ij} - \max_{l \neq j,k} \{v_{il} - c_l\}. \tag{15}$$

That is, the merged entities will not bid against each other, because they have perfect information on the amount of surplus each of their products can offer the customer. If product k was the second-best option for the buyer, the price will rise by an amount that depends on the surplus from the next-best supplier. In instances where the merging firms are not ranked first and second, nothing changes about the realized outcome. Therefore, in assessing the potential effects of a proposed merger, of key interest is how likely the merging firms are to be the first- and second-best suppliers, and the gap between the surplus generated by the merging firms and the next-best supplier.

[45] If the supplier has capacity constraints and is bidding on other procurements, then opportunity costs are relevant. This may be a substantial source of private information, particularly if firms have imperfect information about their competitors' future plans.

This analytical framework is sketched in both in the 1992 and 2010 Guidelines. The 1992 Guidelines reference this issue in terms of supplier cost,

> In some markets sellers are primarily distinguished by their relative advantages in serving different buyers or groups of buyers, and buyers negotiate individually with sellers. Here, for example, sellers may formally bid against one another for the business of a buyer, or each buyer may elicit individual price quotes from multiple sellers. A seller may find it relatively inexpensive to meet the demands of particular buyers or types of buyers, and relatively expensive to meet others' demands. Competition, again, may be localized: sellers compete more directly with those rivals having similar relative advantages in serving particular buyers or buyer groups. For example, in open outcry auctions, price is determined by the cost of the second lowest cost seller. A merger involving the first and second lowest cost sellers could cause prices to rise to the constraining level of the next lowest cost seller.[46]

The 2010 Guidelines are more agnostic on what factors specifically determine the winner of an auction, but continue with the emphasis on first and second choices,

> Anti-competitive unilateral effects in these settings are likely in proportion to the frequency or probability with which, prior to the merger, one of the merging sellers had been the runner-up when the other won the business. These effects also are likely to be greater, the greater advantage the runner-up merging firm has over other suppliers in meeting customers' needs.[47]

We turn now to the methods that have been designed to tackle these questions.

3.2 Merger Simulation and Reduced-Form Analysis

Although there are a number of empirical tools used in assessing unilateral effects, such as the merger simulation and UPP methods discussed in Section 2, the majority of them have appeared in the context of differentiated products sold via Bertrand competition. Analogous work on mergers with auctions is more scarce, particularly when considering tools aimed at practitioners. This may in part be due to a divergence between the focus of the academic literature on auctions, which has often emphasized nonparametric identification or applications to specific contexts such as natural resource auctions

[46] 1992 Guidelines, §2.21.
[47] 2010 Guidelines, §6.2.

or bid rigging, and that of the merger reviewing agencies. The existing work that does appear falls, broadly speaking, into two categories: (1) second-score or second-price merger simulations, and (2) reduced-form analysis of win/loss data or bids.

Merger Simulation

Auction merger simulations appeared in the trials for *Sysco/US Foods* (2015), *Anthem/Cigna* (2016), and *Wilhelmsen/Drew Marine* (2018). In these instances, the experts testifying for the FTC or the DOJ used a second-score auction framework of the type discussed earlier in this section.[48]

As is true in most merger simulations, these auction simulations rely on specific structural assumptions in order to generate predictions for price effects. A key assumption pertains to the distribution of surplus (recall: surplus is value less costs), which in turn determines the expected price change. Miller (2014, 2017) proposes a logit formulation that results in tractable, closed-form expressions. Specifically, Miller (2017) shows that the pre-merger expected markup for firm j, conditional on j winning an auction, is given by

$$E[p_j - c_j | j \text{ wins}] = \frac{1}{s_j}\sigma \ln\left(\frac{1}{1-s_j}\right), \tag{16}$$

where s_j is the market share of firm j, and σ is a scaling parameter that governs the variance of consumer values. Thus, σ can be calibrated from a markup and market shares. With a merger of firms j and k, the markup becomes

$$E[p_j - c_j | j \text{ wins}] = \frac{1}{(s_j+s_k)}\sigma \ln\left(\frac{1}{1-s_j-s_k}\right), \tag{17}$$

which reflects the increase in markup that occurs once firms j and k stop bidding against each other. Alternatively, with market shares alone, the weighted-average percentage increase in the merging firms' markups can be obtained:

$$\dot{m} = \frac{\ln(1-s_j-s_k)}{\ln(1-s_j)+\ln(1-s_k)} \tag{18}$$

The higher markups imply higher prices and lower consumer surplus. Post-merger market shares remain the same as pre-merger because the merged firms continue to

[48] See the *Sysco/US Foods* Memorandum Opinion at pages 89-92, discussing testimony by Mark Israel on behalf of the FTC, the *Anthem/Cigna* district-level Memorandum Opinion at pages 58-59 and 66-67, discussing testimony by David Dranove on behalf of the DOJ, and the *Wilhelmsen/Drew Marine* Memorandum Opinion at pages 44-45, discussing testimony by Aviv Nevo on behalf of the FTC.

bid as before against non-merging rivals.

It is interesting to compare and contrast the logit second-score auction simulation with its logit Bertrand counterpart. In both instances, consumer preferences consist of a deterministic portion capturing quality and price alongside a logit random component. The purchase probabilities have the same logit form. The only difference arises in how prices are set. In order to investigate this issue, we generated a series of logit second-score auction simulations in the same manner as for the Bertrand simulations discussed in Section 2. The resulting effect on prices across the two models is strongly positively correlated, with, for example, a correlation coefficient of 0.96 for markets with four pre-merger firms. The levels are similar at values below 5%, and diverge somewhat more as the effects grow in size.

Given that one could conceptualize the Bertrand game as a first-price auction and the existence of revenue equivalence theorems, it seems that the key distinction between the models lies in the information assumptions on what sellers know about buyer preferences. In the second-score auction model, the merging sellers know the value of the random component of consumer payoffs, which causes them to withdraw the lower value product in each auction. The market shares and prices of other competitors are not affected. In the Bertrand model, sellers only observe the distribution of the logit shock. The merging firms raise prices for all customers, which induces changes in market shares and prices for all rivals.

Win/Loss and Bid Analysis

The typical reduced-form analysis of mergers and auctions attempts to answer the questions as to whether the merging firms are likely to be the first- and second-best options for buyers and, if so, how much of an advantage they have on the third-best. In effect, these types of exercises are loose attempts to mirror the UPP calculation but for auctions. Comparing equations (14) and (15), we see that the expected increase in price for product j is

$$pr_{jk}E[(v_{ik} - c_k) - \max_{l \neq j,k}\{v_{il} - c_l\} | j \text{ wins}, k \text{ is second}], \tag{19}$$

for a merger between suppliers j and k, where pr_{jk} is the probability that j is the first choice and k is the runner-up. The probability that the merging firms are first and second is a similar concept to diversion, whereas the gap in surplus between the second and third bidders is related to the markup, although these terms are not identical

to their UPP counterparts. In merger review, one or both of these objects may be measured.

Procurement settings typically generate data on individual auctions or RFPs. Frequently these data list who the winner was, sometimes with the realized price, along with some subset of the following information: (1) for products or services that are purchased repeatedly, who the last supplier was, which is sometimes called "win/loss" data; (2) the identity of the non-winning bidders; or (3) more rarely, the value of the non-winning bids. Data sets of the first two types are used to form an assessment of the probability that the merging firms are first and second, whereas data of the third type can be used to calculate sample values for expression (19) directly.

In *Quest Diagnostics/Unilab* (2003), the FTC had information sufficient to show that the merging firms were the first- and second-lowest bidders for a significant percentage of customers and argued that prices would rise to the level dictated by the third-lowest supplier.[49] Experts testifying on behalf of the DOJ in the *Oracle/PeopleSoft* (2004) trial showed data and regressions indicating that when PeopleSoft was present in an RFP, Oracle offered more discounts.[50] In the *Bazaarvoice/PowerReviews* (2013) trial, the DOJ presented evidence that PowerReviews was the competitor identified with the highest frequency in RFPs that Bazaarvoice participated in.[51] During the trial for *Staples/Office Depot* (2016), the FTC cited data and documents indicating that Staples and Office Depot frequently had the two best bids or were the last two bidders competing for large business customers.[52]

One of the most commonly available types of data is win/loss. From this information, one can calculate a switching or churn ratio, n_{jk}/N_j, where n_{jk} is the number of customers switching from firm j to firm k, and N_j is the total number of customers switching from j to any other option. This value is frequently used as a measure of pr_{jk}, although depending on the customers' reasons for switching, the churn ratio may not align with the ranking probability.[53] A common benchmark is how the churn ratio compares to what diversion according to share would predict.[54]

[49] 2006 Commentary, §2.

[50] See the demonstrative exhibits used by Kenneth Elzinga and Preston McAfee, available at `https://www.justice.gov/atr/usdoj-antitrust-division-us-and-plaintiff-states-v-oracle-corporation`.

[51] See the Memorandum Opinion at paragraphs 267-273, discussing testimony by Carl Shapiro on behalf of the DOJ.

[52] See the Memorandum Opinion at pages 57-58, citing analysis done by Carl Shapiro on behalf of the FTC.

[53] Relatedly, Chen and Schwartz (2016) show how the churn ratio may depart from diversion.

[54] Diversion according to share is given by $d_{jk} = s_k/(1 - s_j)$, where s_j is the market share of firm j.

In *Express Scripts/Medco* (2012), the FTC calculated the churn ratio for RFPs done for pharmacy benefit services and found that the merging firms experienced significant churn to other competitors, even though the combined firm would account for 40% of the market.[55] The FTC subsequently did not challenge the transaction. As part of the economic analysis that appeared in the trial for *Anthem/Cigna* (2016), the DOJ presented churn ratios showing that the share of switches accounted for by Anthem when Cigna was the incumbent and vice versa were larger than would be predicted by either firm's market share.[56]

3.3 Powerful Buyers

Auction settings often involve buyers that are themselves large firms, rather than a pool of atomistic consumers. This raises the question of whether these buyers can protect themselves from the negative consequences of a merger among their suppliers. The 2010 Guidelines state that

> The Agencies consider the possibility that powerful buyers may constrain the ability of the merging parties to raise prices. . . . However, the Agencies do not presume that the presence of powerful buyers alone forestalls adverse competitive effects flowing from the merger. Even buyers that can negotiate favorable terms may be harmed by an increase in market power.[57]

Consistent with this statement, the research on mergers in auctions and bargaining games indicates that consumer harm can arise in these contexts.

Waehrer and Perry (2003) and Loertscher and Marx (2019) allow buyers to set one or more reserve prices. In the Waehrer and Perry (2003) model, the reserve price applies uniformly to all suppliers. Mergers can induce buyers to decrease the reserve price as a counterbalance to greater supplier market power. By contrast, in the Loertscher and Marx (2019) model, buyers use discriminatory reserve prices to advantage weaker suppliers. In both cases the use of reserve prices may allow customers to mitigate the harm from mergers, but not to eliminate it. In a related finding, Bulow and Klemperer (1996) show that the buyer gains more from having an additional bidder in an English auction than from having the ability to negotiate with a seller, even when the buyer

[55] See Shelanski et al. (2012).

[56] See the demonstrative exhibit used by David Dranove at pages 46-46, available at `https://www.justice.gov/atr/page/file/914606/download`.

[57] 2010 Guidelines, §8.

can make take-it-or-leave-it offers. Thus, a loss of competition is not fully remedied by a powerful buyer.

This issue also appears in a related class of models, those on bargaining. Certain procurement contexts, particularly those that involve long negotiations, are sometimes modeled as bargaining games instead of auctions. The leading examples are the purchase of healthcare services and of television programming. In these models, the presence of bargaining power can lessen the harm from a merger between substitute suppliers, but typically does not fully offset it.

Gowrisankaran et al. (2015) use a bargaining framework to study the proposed *Inova Health System/Prince William Hospital* (2006) merger and find that it would have resulted in substantial price increases. The FTC challenged the transaction, and it was later abandoned. Farrell et al. (2011) discuss the bargaining model as it is applied to hospital mergers. The FTC also relied on a bargaining model in the *St. Luke's Health System/Saltzer Medical Group* (2013) trial to show how the acquisition of a large physician group by a health system could increase their combined bargaining leverage.[58] A similar model was used in the FCC investigation of the proposed *Comcast/Time Warner Cable* (2014) merger.[59] Sheu and Taragin (2020) show how bargaining models of this type can be calibrated with data commonly available to the antitrust agencies and then used for merger simulations.

4 Homogeneous Products

Much of the early game-theoretical literature on mergers examined the properties of Cournot equilibrium (e.g., Salant et al. (1983); Perry and Porter (1985); Farrell and Shapiro (1990)). The subsequent empirical literature, however, has focused more on differentiated products and auctions, and there have been relatively fewer recent modeling innovations for homogeneous products. The 2010 Guidelines thus largely track the 1992 Guidelines, albeit with a somewhat more expansive discussion.[60]

[58] See the demonstrative exhibit used by David Dranove when testifying on behalf of the FTC, at slides 12-16, available at `https://www.ftc.gov/system/files/documents/cases/131002stlukedemodranove.pdf`.

[59] See the discussion in the "Proposed Comcast-Time Warner Cable-Charter Transaction Economic Analysis Workshop," the transcript of which is available at `https://ecfsapi.fcc.gov/file/60001031131.pdf`. In this case the merger was one between buyers, not suppliers. The transaction was subsequently abandoned.

[60] It is telling that the Shapiro (2010) article on the drafting of the 2010 Guidelines mentions homogeneous products only in passing.

4.1 Analytical Framework

The typical analysis emerges from the Cournot model of oligopoly competition among suppliers of a homogeneous product. Each firm produces at an output level that maximizes its profit, conditional on the output of competitors. Firms in this context face the trade-off that output reductions raise the market price but reduce the quantity sold by the firm. These countervailing effects balance in equilibrium, where again marginal revenue equals marginal cost.[61] Mergers create an incentive for each merging firm to reduce output because its merging partner benefits from the higher market price. Farrell and Shapiro (1990) prove that, absent efficiencies, merging firms reduce their output in equilibrium and non-merging firms increase output by a lesser amount in response, such that total output falls and the market price increases.

Consistent with this reasoning, the 2010 Guidelines state:

> In markets involving relatively undifferentiated products, the Agencies may evaluate whether the merging firm will find it profitable unilaterally to suppress output and elevate the market price.[62]

Similar language appears in the 1992 Guidelines, §2.22, but the 2010 Guidelines push a bit further and enumerate conditions under which unilateral effects are likely to be more pronounced:

> A unilateral suppression of output is more likely to be profitable when (1) the merged firm's market share is relatively high; (2) the share of the merged firm's output already committed for sale at prices unaffected by the output suppression is low; (3) the margin on the suppressed output is relatively low; (4) the supply responses of rivals are relatively small; and (5) the market elasticity of demand is relatively low.[63]

Each of these considerations arises from a game-theoretical analysis of mergers in Cournot equilibrium.[64] However, this "checklist" approach can leave merger review

[61] The first order conditions of equation (1) apply with the simplification that $\partial q_i/\partial p_i = \partial Q/\partial p$, for all i, given market quantities $Q \equiv \sum_i q_i$ and market price p.

[62] 2010 Guidelines, §6.3.

[63] 2010 Guidelines, §6.3.

[64] The only consideration that does not emerge from a one-shot game of simultaneous production is (2), which can be an important consideration, especially in the presence of forward markets. A caveat to the Guidelines language is that merging firms have an incentive to reduce output commitments, such that forward markets can amplify rather than mitigate price effects (Miller and Podwol (2020)).

unsettled if market facts are ambiguous—for example, if the market shares of the merging firms are low but market demand is inelastic. Just as with differentiated-products mergers, analyses that are tightly linked to the underlying theoretical model allow for multiple considerations to be evaluated jointly. This may provide a more accurate prediction of merger effects than an evaluation of specific market facts in isolation.

4.2 Quantitative Methods

Perhaps the model most amenable to calibration and simulation is that of Perry and Porter (1985), which features a linear market demand curve and firm-specific marginal cost curves of the form $mc_i = q_i/k_i$, where k_i represents capital. Thus, the model embeds that marginal costs increase with output, which has theoretical importance because otherwise the output expansion of non-merging firms tends to be large enough to render a merger unprofitable. It also matches the stylized fact that the production of chemicals, metals, and other industrial products often is limited by capacity constraints. The marginal cost function is the dual of the Cobb-Douglas production function, $q_i = \sqrt{k_i M_i}$, where M_i is the variable factor. The model can be calibrated with data on market shares, total quantity, and price. Alternatively, denoting as $\bar{q}_i$ as the maximum that firm i can economically produce at prevailing market prices, it is possible to recover the capital terms as $k_i = \bar{q}_i/p$, such that data on capacity can substitute for data on output. With both sets of data, or margins, marginal cost intercepts can be incorporated, and over-identification checks can be conducted.[65]

If the parametric assumptions of the Perry and Porter (1985) model are inappropriate in a particular setting, then a CMCR approach can be applied (Froeb and Werden (1998); Nocke and Whinston (2020)).[66] Let the share-weighted marginal cost of the merging firms be c^0. After the merger, cost minimization dictates production at a level that equates the marginal costs of the merging firms' plants; incorporating any efficiencies, let this cost be c^1. Finally, defining $\dot{c} \equiv (c^0 - c^1)/c^0 > 0$ as the percentage reduction

[65]The code we use for the calibration and simulation of this model tracks the equations derived in McAfee and Williams (1992). See also Farrell and Shapiro (1990) and Werden (1991).

[66]See Jaffe and Weyl (2013) for a generalized expression for the UPP formula that nests differentiated-products Cournot as a special case. As the amount of differentiation decreases, converging toward the homogeneous-products case, UPP tends to zero but the pass-through of UPP to equilibrium prices tends to infinity. This mathematical difficulty makes the CMCR approach more useful than UPP for homogeneous-products markets.

in marginal cost due to the merger, the market price increases if and only if

$$\dot{c} < \frac{2s_j s_k}{\epsilon(s_j + s_k) - (s_j^2 + s_k^2)}, \tag{20}$$

where $\epsilon > 0$ is the demand elasticity.[67] With symmetric firms, this is equivalent to

$$\dot{c} < \frac{s}{\epsilon - s}. \tag{21}$$

Thus, for example, with market shares of 0.20 and a market elasticity of one, the merger increases price unless marginal cost decreases by at least 25 percent. This calculation requires no parametric assumptions on the demand or cost functions.

These methods were used in the recent *Tronox/Cristal* (2018) merger trial, which involved the market for chloride-process titanium dioxide.[68] Given market shares and an estimate of the market elasticity of demand, it was inferred that the merger would have to reduce marginal costs by 74% or more to prevent price increases. The FTC argued that such efficiencies were implausible. The defendants countered that, because simulation indicated that the merger would be unprofitable, the Cournot framework was inappropriate for the setting. This argument strikes us as reflecting a misunderstanding of the CMCR approach, which is flexible enough to accommodate convex demand and/or arbitrarily constrained non-merging firms, and therefore is always consistent theoretically with profitable Cournot mergers.[69]

Of course, few industries feature perfectly homogeneous products. For example, even if firms produce identical output, transportation costs may create spatial differentiation, and firms may differ in their ability to deliver reliably and on schedule.[70] Such differences do not necessarily render the Cournot model unhelpful in merger analysis. However, if consumers perceive that some firms' products are substantially closer substitutes than others, then an alternative approach may be warranted. One

[67] See Froeb and Werden (1998). Nocke and Whinston (2020) provide an equivalent equation in which the change in the HHI, $\Delta\text{HHI} = 2s_j s_k$, appears on the right-hand-side.

[68] See Greenfield et al. (2019) and the Memorandum Opinion at page 33, discussing testimony by Nicholas Hill on behalf of the FTC. The FTC also applied a modeling framework designed to predict capacity reductions, developed in Hill (2008). The 2010 Guidelines, §6.3, point out that capacity reductions are one way to implement output suppression.

[69] The observation that Cournot mergers with constant marginal cost and linear demand tend to be unprofitable was made originally in Salant et al. (1983). The result depends on particular modeling assumptions: profitability is restored if capital is incorporated and the merging firms are sufficiently large (Perry and Porter (1985)) or if demand is convex (Fauli-Oller (1997); Hennessy (2000)).

[70] The 2010 Guidelines, §6.3, describe homogeneous products as being "relatively undifferentiated."

possibility is a Bertrand model in which transportation costs create localized market power for capacity-constrained suppliers, and equilibrium prices reflect the proximity of consumers to each plant and its competitors. Estimation can be accomplished with transaction-level data from the relevant suppliers or with aggregate data on prices and quantities (e.g., see the Miller and Osborne (2014) model of the cement industry). Another possibility is a differentiated-products Cournot model, though we are not aware of empirical research that explores that option.

5 Game Theory and Market Concentration

As merger analysis has evolved from the original 1968 Guidelines through the 2010 Guidelines to today, there has been an increasing focus on understanding the precise mechanisms by which mergers affect competition. This affects the types of evidence that the antitrust agencies seek to gather and how the evidence is interpreted, with the ultimate goal of better assessing the competitive effects of each merger as it arises in its own unique circumstances. Merger review increasingly has incorporated the game-theoretical methods described earlier in this article—an evolution "from hedgehog to fox," as characterized by Shapiro (2010). However, screens based on market shares and market concentration remain the legal standard and continue to be presented in court.[71] In this section, we develop the way in which the two approaches relate to each other in a unified framework. As a byproduct, our analysis suggests a modification to current practice that could better align screens with economic theory.[72]

5.1 Merger Effects and HHI

The 2010 Guidelines state that mergers that generate a post-merger HHI above 2,500 and a ΔHHI above 200 "will be presumed to be likely to enhance market power."[73] A connection between unilateral effects and the ΔHHI, in particular, has been understood

[71] For an example of how these screens have been applied in litigation, see the demonstrative exhibit used by Aviv Nevo as part of the *Aetna/Humana* (2016) trial, slides 56-61, available at `https://www.justice.gov/atr/page/file/918706/download`.

[72] The 2010 Guidelines define a relevant antitrust market as comprising a set of products for which a hypothetical monopolist would find it profitable to impose a small but significant price increase. There are straight-forward connections between the models that we have discussed for unilateral effects and those that are used to evaluate candidate markets. It is worth noting, however, that the finding of a significant GUPPI for products of the prospective merging firms can indicate that those products—by themselves—constitute a relevant market.

[73] 2010 Guidelines, §5.3.

to exist for some time (e.g., Froeb and Werden (1998), Shapiro (2010)).[74] Recent theoretical findings have shown that ΔHHI provides a good approximation for consumer surplus loss in the Bertrand logit model (Nocke and Schutz (2019)), and that the compensating efficiencies in the Cournot and Bertrand logit models can be expressed in terms of ΔHHI (Nocke and Whinston (2020)).

We provide a set of numerical results to supplement the literature on this point. We construct markets with either two, three, or four firms (plus an outside good), randomly draw 500 market share vectors for each, and then consider a merger between the first two firms. We obtain the percentage change in consumer surplus and markups for the Bertrand logit model using the partial calibration approach of Caradonna et al. (2020). We also apply equation (18) to obtain the percentage change in markups for the second-score auction model of Miller (2014, 2017). Finally, we use equation (20) to obtain the Cournot CMCR, assuming unit demand elasticity. Figure 2 plots the results. All of the measures are highly correlated with ΔHHI.[75]

[Figure 2 about here.]

Thus, in some of the most commonly-used models in merger review, there is no tension between screens based on ΔHHI and the game-theoretical methodologies described in the 2010 Guidelines for unilateral effects analysis. Rigorous game-theoretical modeling reinforces the usefulness of share-based analyses, rather than making them obsolete. Thus it is that the following statements of Shapiro (2010) fit together:

> Many observers have noted specifically that the 2010 Guidelines place less weight on market shares and market concentration than did predecessors. This is a central example of the fox's eclectic approach, tailoring the methods used to the case at hand and to the available evidence.[76]

[74] Froeb and Werden (1998) consider the Cournot case that has already been discussed. Shapiro (2010) provides an approximation for the Bertrand logit context. Consider a merger that involves two products with pre-merger market shares s_j and s_k. With logit demand, diversion from product j to product k equals $s_k/(1-s_j)$ and can be approximated by $s_k(1+s_j)$ for small s_j. Diversion from k to j is analogous, so the sum of the approximate diversion ratios is $s_j + s_k + 2s_j s_k$ or $s_j + s_k + \Delta\text{HHI}$.

[75] The results we obtain with the Bertrand and second-score models depend on a stochastic assumption that we discuss in the next subsection. We evaluate ΔHHI at pre-merger market shares, with the shares calculated among the inside goods. This is a slight departure from Nocke and Schutz (2019), in which the shares are calculated among all goods, including the outside good. We exclude the outside good in the Cournot analysis.

[76] Shapiro (2010), page 707.

> [L]ike the fox, the 2010 Guidelines embrace multiple methods. But this certainly does *not* mean they reject the use of market concentration to predict competitive effects....[77]

Conditional on the ΔHHI, the *level* of HHI tends to be unimportant for the unilateral effects of mergers. This is especially true with Bertrand models and the second-score model (or efficient auctions more generally). In the former, the division of share among non-merging firms matters only to the extent it effects the strategic complementary of prices. In the latter, the non-merging firms do not effect the impact of the merger on percentage markup changes, given the shares of the merging firms (e.g., equation (18)). The 2006 Commentary on the Guidelines, §1, notes that for unilateral effects "[t]he concentration of the remainder of the market often has little impact on the answer...."

The natural enforcement implication is that screening mergers for unilateral effects based only on the ΔHHI would help align antitrust practice with economic theory.[78] We do not intend to suggest that the level of HHI is uninformative in merger review. Indeed, for theories of harm involving coordinated effects or potential competition, it may be more relevant than ΔHHI.[79] Pairing the ΔHHI for unilateral effects and the HHI for coordinated effects and potential competition, we arrive upon the suggestion that it could be appropriate for the antitrust agencies to presume adverse effects if the post-merger HHI exceeds 2,500 or the ΔHHI exceeds 200. This presumption would be subject to rebuttal, given contrary evidence on efficiencies or on a lack of anti-competitive effects for other reasons. We would view such a change as consistent with the evolution of merger review "from hedgehog to fox." We also suspect it could be (perhaps surprisingly) effective in invigorating merger review—though its ultimate impact would depend on courts' willingness to endorse new standards.[80]

Such a change would imply a presumption of harm if, for example, the merging firms have market shares of 10 and 15 percent, and all other firms are infinitesimal.

[77] Shapiro (2010), page 708.

[78] A similar conclusion is reached by Nocke and Whinston (2020), who state, "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 their unilateral effects will harm consumers."

[79] Efforts to link the HHI to coordinated effects date at least to Stigler (1964). For recent treatments linking concentration and the number of firms to coordination, see Ivaldi et al. (2007) and Baker and Farrell (2020). Antitrust concerns about a lessening in potential competition could arise, for example, in situations involving a dominant firm acquiring a promising smaller firm (Cunningham et al. (2020)). See Werden and Limarzi (2011) for an insightful discussion of potential competition under current practice.

[80] A full examination of such a new standard, across the myriad of mergers encountered in practice, is beyond the scope of this article.

This yields a ΔHHI of 300 and a post-merger HHI of 625. Such a transaction might substantially increase market power absent countervailing efficiencies. Applying the second-score model for illustrative purposes, such a merger would increase markups by 7.4%, enough to raise possible concern. Whether the percentage changes are economically meaningful in absolute terms—which could be informed by the magnitude of margins, for example—would be a focus for competitive effects analysis and could impact the ultimate enforcement decision.

5.2 The Logit Assumption in Narrow Antitrust Markets

The Bertrand and second-score results shown in the previous section depend on logit assumptions: demand is logit in the first case and the distribution of surplus (value less costs) is logit in the second. This implies that diversion is *proportional to market share*, in the sense that the relative diversion from any product i to any two other products k and j takes the form: $d_{ij}/d_{ik} = s_j/s_k$.[81] This property is also known as the "Independence of Irrelevant Alternatives" (IIA). If diversion-by-share fails, then the ΔHHI can be misleading about unilateral effects, in either direction. However, diversion-by-share often is a decent approximation within narrowly defined antitrust markets.

The reason this is the case might best be illustrated with an example. Take automobiles. It seems implausible that diversion from a BMW sedan to the Ford F-150 pickup truck would exceed diversion to a Mercedes sedan. Yet, given the popularity of the Ford F-150, that is what would be implied by proportional diversion. Thus, the logit model would be a poor representation of product-level substitution among all automobiles. For this reason, academic research tends to feature the random coefficients logit model (Berry et al. (1995); Nevo (2001); Miller and Weinberg (2017)), which allows for more flexible consumer substitution among heterogeneous products. This is appropriate because such academic studies often examine competitive interactions across broad product categories (such as automobiles).

Antitrust markets defined for the purposes of merger review, however, often focus on narrower sets of products, following the logic of the hypothetical monopolist test. Consider a merger between BMW and Mercedes. It seems likely that a hypothetical monopolist of luxury automobiles would raise price. Thus, the relevant antitrust mar-

[81] In the second-score model of Miller (2014, 2017), consumers substitute to competitors in proportion to their market share if one firm's value or cost changes. We refer to this as diversion for brevity.

ket would be comprised of much more comparable products.[82] Even in the random-coefficients logit model, diversion-by-share emerges as products become more similar in their attributes, suggesting that the logit model often provides a good representation of narrowly defined antitrust markets. Consistent with this line of thought, merger review often maintains the diversion-by-share assumption, at least as an analytical starting point.[83] So long as this is reasonable, the connections between HHI and merger effects explored in this section would seem broadly applicable in merger review.

6 Conclusion

We have described what we view as state-of-the-art quantitative modeling techniques for merger review in unilateral effects cases, and discuss the role that the 2010 Guidelines have played in legitimizing these techniques and motivating research. Antitrust economics, and merger review specifically, continues to be a fruitful subject for intellectual inquiry. Indeed, among the articles and books that we cite here, more than half were published *after* the 2010 Guidelines, representing contributions from academics, agency economists, and antitrust consultants. There is an ongoing interplay between scholarly researchers and policymakers, with each informing each other, and which we hope will be an important source of new knowledge.

Two other articles in this issue also address unilateral effects. Valletti and Zenger (2020) focus on differentiated products and innovation. Regarding the former, they derive useful relationships between UPP, CMCRs, and simple merger simulations that are not provided here. On the latter, they highlight how the 2010 Guidelines contributed to an understanding of how mergers can affect innovation incentives. Throughout, the article discuss how quantitative modeling has been used in European cases, a nice complement to our focus on merger review in the United States.

The second article is Carlton and Israel (2020), which provides a set of observations and recommendations, drawing on the authors' practical experience with merger review. For example, it provides useful discussions of natural experiments and merger retrospectives—subjects that we have omitted here only due to various constraints. Our viewpoints differ from Carlton and Israel on some of the topics discussed, and

[82] Example 7 in the 2010 Guidelines, §4.1.1, makes the same point using cars and motorcycles.

[83] See the Memorandum Opinion for *H&R Block/TaxACT* (2011) at page 76, or the demonstrative exhibit used by David Dranove during the *Anthem/Cigna* (2016) trial at page 48, available at `https://www.justice.gov/atr/page/file/914606/download`, for example.

we take this opportunity to clarify for readers the bases for these differences. Regarding UPP, Carlton and Israel state the "UPP is a great concept for creating intuition for why harm can occur from a merger but a poor one for deciding when to challenge a merger." The authors' skepticism about UPP derives in part from the observation that the predictive accuracy of UPP deteriorates in the presence of efficiencies (e.g., see our Section 2.4). We are more optimistic because, in our own experience, mergers on the enforcement margin often appear unlikely to generate substantial efficiencies. Still, we agree that other tools, such as merger simulation and CMCR, are more reliable for assessing countervailing forces. Regarding market concentration and HHIs, Carlton and Israel state that "[m]arket definition, with the associated market shares, is just a crude, imprecise predictor of a merger's effects." This leads them to a policy recommendation that concentration screens should create at most a weak presumption. We view this as inconsistent with recent research that develops connections between unilateral price effects and the ΔHHI, in particular (e.g., see our Section 5).

Finally, we note that some judicial decisions cite quantitative models and their outputs as helpful pieces of evidence, whereas others have ignored or dismissed them. On the one hand, we have the Memorandum Opinion for *H&R Block/TaxACT* (2011):

> The Court finds that the merger simulation model used by the government's expert is an imprecise tool, but nonetheless has some probative value in predicting the likelihood of a potential price increase after the merger. The results of the merger simulation tend to confirm the Court's conclusions based upon the documents, testimony, and other evidence in this case.... [84]

Contrast that with the Memorandum Opinion for *T-Mobile/Sprint* (2020):

> ...[T]he parties' costly and conflicting engineering, economic, and scholarly business models, along with the incompatible visions of the competitive future their experts' shades-of-gray forecasts portray, essentially cancel each other out as helpful evidence the Court could comfortably endorse as decidedly affirming one side rather than the other.[85]

Thus, additional evidence on the usefulness and reliability of these methods, presented in a way that is policy-accessible, would be valuable. Existing research that uses merger retrospectives, examines numerical validation exercises, or draws connections

[84] Memorandum Opinion, page 78.
[85] Memorandum Opinion, pages 4-5.

to recent investigations has had a visible influence on work done by the antitrust agencies, particularly since the release of the 2010 Guidelines. An important next frontier may be to increase the acceptance of these tools in litigation, thereby cementing the evolution from "hedgehog to fox" in the courtroom.

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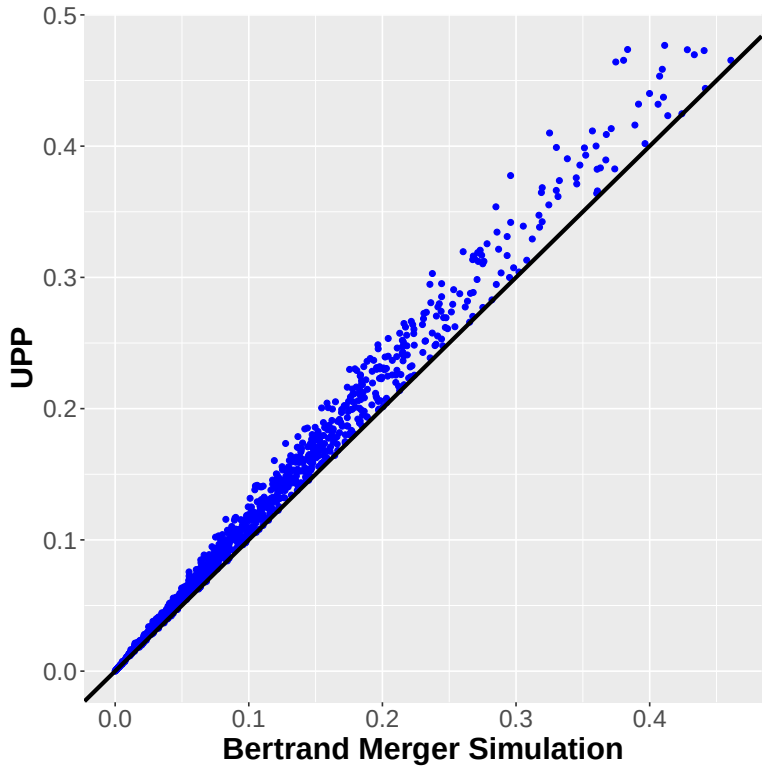

Figure 1: UPP and Merger Price Effects

Notes: The figure presents the results of a Monte Carlo experiment in which models of Bertrand competition with logit demand are calibrated to match 500 randomly drawn data sets. A merger between two firms is considered. Each dot provides the value of UPP for one merging firm (on the vertical axis) and the corresponding price increase implied by Bertrand merger simulation (on the horizontal axis). Because pre-merger prices are normalized to one, the dots also provide the percentage price increases.

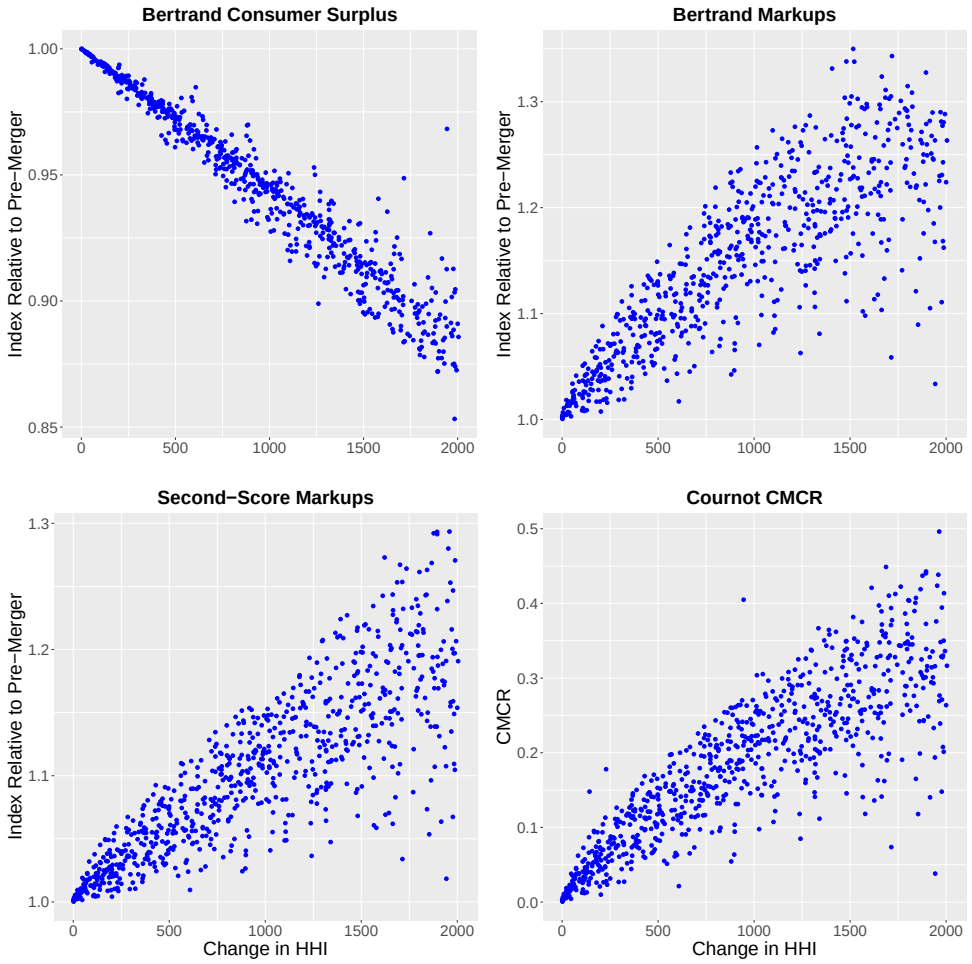

Figure 2: Unilateral Effects and the ΔHHI

Notes: The top panels examine changes in consumer surplus and markups, respectively, in a model of Bertrand price competition and logit demand. The bottom left panel examines changes in markups in a second-score model. The bottom right panel shows the compensating marginal cost reduction (CMCR) in a Cournot model with unit demand elasticity. The horizontal axis in every panel is the ΔHHI.