A Price Leadership Model for Merger Analysis*

Ryan Mansley[†]
Georgetown University

Nathan H. Miller[‡]
Georgetown University

Gloria Sheu[§]
Federal Reserve Board

Matthew C. Weinberg[¶]
The Ohio State University

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Abstract

We provide a methodology to simulate the coordinated effects of a proposed merger using data commonly available to antitrust authorities. The model follows the price leadership structure in Miller, Sheu, and Weinberg (2021) in an environment with logit or nested logit demand. The model calibration leverages profit margin data to separately identify the extent of coordinated pricing from marginal costs. Using this framework, we demonstrate how mergers can shift incentive compatibility constraints and thereby lead to adverse competitive effects. The incentive compatibility constraints also affect the extent to which cost efficiencies and divestitures mitigate competitive harms.

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[†]Georgetown University, Department of Economics, 37th and O Streets NW, Washington DC 20057. Email: rem133@georgetown.edu.

[‡]Georgetown University, Department of Economics, 37th and O Streets NW, Washington DC 20057. Email: nhm27@georgetown.edu.

[§]Board of Governors of the Federal Reserve System, 20th Street and Constitution Avenue NW, Washington DC 20551. Email: gloria.sheu@frb.gov.

[¶]The Ohio State University, 410 Arps Hall, 1945 N High Street, Columbus OH 43210. Email: weinberg.133@osu.edu.

1 Introduction

Antitrust authorities often use model-based simulations to quantify the competitive effects of mergers and to evaluate the possible tradeoffs between adverse competitive effects and efficiencies such as marginal cost reductions (Davis and Garcés, 2009; Miller and Sheu, 2021). This approach was developed in the academic literature under the Nash-Bertrand assumption that each firm sets its prices to maximize its profit, conditional on the prices of competitors (e.g., Berry and Pakes, 1993; Hausman et al., 1994; Werden and Froeb, 1994; Nevo, 2000). As such, the simulations are intended to capture the change in unilateral pricing incentives that is created by the merger.[1]

Mergers also may facilitate collusion and thereby have a "coordinated effect" on market outcomes.[2] Simulation methods for coordinated effects are less well developed. There are a number of challenges. Among these are the folk theorems indicating that there can be many different pricing strategies that may constitute subgame perfect equilibria (SPE) in repeated pricing games, meaning it can be unclear how to select among these equilibria. Furthermore, many canonical models of collusion allow for the possibility that incentive compatibility (IC) constrains the prices that can be sustained in SPE (e.g., Green and Porter, 1984; Rotemberg and Saloner, 1986). Thus, it can be necessary to model how punishment might unfold and how firms tradeoff current and future profit. Faced with these difficulties, coordinated effects analyses in practice often default to identifying characteristics of an industry that make it more or less susceptible to collusion.[3]

In this paper, we examine a modeling framework that can overcome these challenges in specific settings: the model of *oligopolistic price leadership* developed in Miller et al. (2021) (henceforth "MSW"). Our contribution is practical, as we seek to facilitate the appropriate use of the model in merger review. To that end, we simplify the MSW framework to a setting with a single market and logit or nested logit demand. We then show how the model can be calibrated with information that often becomes available to antitrust authorities during the course of merger review. We then explore how a number of different mergers affect

[1]Unilateral effects merger simulations have been presented as economic evidence in a number of recent merger cases in the United States and Canada. Examples include *H&R Block/TaxACT* (2011), *AT&T/DirecTV* (2015), *Aetna/Humana* (2016), *Wilhelmsen/Drew Marine* (2018), *Parrish & Heimbecker/Louis Dreyfus Company* (2021), and *Secure/Tervita* (2022).

[2]We do not distinguish between express and tacit collusion in this paper, as it would not substantively affect the economic analysis. Coordinated effects also can encompass parallel accommodating conduct, such as mimicking rival firms or other related business practices.

[3]This "checklist" approach is typified by the list of factors discussed in §7.2 of the 2010 *Horizontal Merger Guidelines* of the Department of Justice and the Federal Trade Commission.

equilibrium outcomes in the model, and examine the conditions under which efficiencies and divestitures mitigate adverse competitive effects. We also discuss the settings for which the modeling framework may be appropriate.

We organize the paper as follows. We start with the model of price leadership in Section 2. The model is a repeated two-stage game of perfect information. In the first stage of each period, the leader announces a *supermarkup* to be applied above Nash-Bertrand prices by members of a coalition. In the second stage, all firms set prices simultaneously. Along the equilibrium path, the leader selects the supermarkup that maximizes its profit subject to the IC constraints of the coalition firms, and the coalition firms adopt the supermarkup in the subsequent pricing stage. Thus, although the leader's announcement is cheap talk, it provides a coordination device that resolves (by assumption) the multiple-equilibrium problem. The model incorporates a set of fringe firms that price to maximize static profit functions. A merger in this context can affect the IC constraints and thus the magnitude of the supermarkup that emerges in SPE.

The model is intended to provide a reasonable representation of a pricing practice that has been observed across a range of settings. In 1964, the United States Supreme Court ruled that price leadership in the tobacco industry violated the Sherman Act, and this motivated the earliest academic articles on the subject (e.g., Stigler, 1947; Markham, 1951; Oxenfeldt, 1952; Bain, 1960). Anecdotal examples of price leadership are discussed in Scherer (1980), Lanzillotti (2017), and Harrington (2017), and evidence of price leadership has been considered in a number of price-fixing lawsuits when courts have weighed whether discovery should be granted to the plaintiffs.[4] Recent empirical applications document follow-the-leader pricing in retail industries including supermarkets, pharmacies, gasoline, and beer (Clark and Houde, 2013; Seaton and Waterson, 2013; Chilet, 2018; Lemus and Luco, 2021; Byrne and de Roos, 2019; Miller et al., 2021). We suspect price leadership may be (at least somewhat) prevalent because it simplifies the process through which coordinating firms select prices. Thus, what is convenient from a modeling standpoint—that the leader's announcement effectively selects among the SPE that are generally available under the folk theorems—may also be convenient for the firms involved.

In Section 3, we develop how the primitives of the model can be calibrated to match information that often becomes available to antitrust authorities during merger review. Here

[4]Examples include firms involved in flat glass (*Re: Flat Glass Antitrust Litig.*, 385 F.3d 350 (3rd Cir 2004)), text messaging (*Re: Text Messaging Antitrust Litig.*, 782 F.3d 867 (7th Cir 2015)), titanium dioxide (*Re: Titanium Dioxide Antitrust Litig.*, RDB-10-0318 (D. Md. 2013)), and chocolate (*Re: Chocolate Confectionary Antitrust Litig.*, 801 F.3d 383 (3rd Cir 2015)).

we depart from MSW, which pairs demand estimates for the beer market with a supply-side orthogonality condition.[5] Our focus reflects that what is possible in merger review can differ from what is possible for academic research. Specifically, in merger review, the time and data necessary for sophisticated demand estimation may be unavailable whereas, subject to the usual caveats, data on equilibrium objects such as margins and diversion may be possible to obtain from accounting data or confidential business documents (e.g., Davis and Garcés, 2009; Miller and Sheu, 2021). With logit demand, calibration can be accomplished with as little as market shares, prices, two margins, and a diversion ratio. With somewhat more information, a nested logit demand system can be calibrated to allow for richer consumer substitution patterns. We illustrate by calibrating a version of the model using statistics on the beer industry presented in MSW; our results are similar to what is obtained using the estimation-based approach of MSW.

We end the paper by exploring the antitrust implications of horizontal mergers in industries characterized by price leadership (Section 4). Using simulations, we first show how prices change as concentration increases in a market with symmetric firms. Under price leadership, prices can rise much more quickly with concentration than under a standard Nash-Bertrand equilibrium, and near-monopoly prices can be attained at relatively low levels of concentration. The differences between price leadership and Nash-Bertrand become more significant if firms are patient in valuing future profit. We then examine a variety of horizontal mergers in a market with asymmetric firms. Mergers involving the coalition firm with the binding IC constraint can have outsize effects on prices and welfare, as these mergers tend to relax the IC constraint and thereby result in higher equilibrium supermarkups. Another class of mergers that can have large effects involves the acquisition of a fringe firm by a coalition firm—the merged firm internalizes that the price of the fringe product affects IC constraints within the coalition, and this can amplify upward pricing pressure.

We also show that price leadership can change the ability of efficiencies and divestitures to mitigate the effects of a merger. When the merger in question involves the firm with the binding IC constraint, the level of efficiencies required to offset the price effects of a merger can be substantially higher under price leadership than under Nash-Bertrand. However, this may not be the case for mergers that do not include the IC-binding firm. Furthermore, the effectiveness of divestitures is significantly more complicated under price leadership than Nash-Bertrand because divestitures may change which products are in the coalition. We show that if a coalition product is divested to a fringe firm, the resulting prices depend on

[5] The specific supply-side orthogonality assumption used is that the marginal costs of Anheuser-Busch did not change with the Miller/Coors joint venture differently from the costs of Modelo and Heineken.

whether the recipient of the divested product joins the coalition. Divestitures can be highly effective if the recipient firm is unlikely to join the coalition; in some cases welfare may even be higher than before the merger. However, the benefits of a divestiture are reduced if the recipient firm joins the coalition.

We conclude in Section 5 with a brief summary, a discussion about the applicability of the model, and directions for future research. Our work contributes to a broad literature that develops and evaluates methodologies with which to analyze the competitive effects of mergers. Two contributions that are close to our own are Moresi et al. (2015) and Igami and Sugaya (2021), which focus on understanding coordinated effects outside of the price leadership context. More research analyzes unilateral effects. Among the topics that have been examined are upward pricing pressure (e.g., Farrell and Shapiro, 2010; Jaffe and Weyl, 2013; Moresi and Salop, 2013; Miller et al., 2016, 2017; Greenfield and Sandford, 2021) and auction models and bargaining (e.g., Waehrer and Perry, 2003; Miller, 2014; Loertscher and Marx, 2019; Sheu and Taragin, 2021). Other research explores the accuracy of modeling or the extent to which specific modeling choices affect inferences (e.g., Peters, 2006; Weinberg and Hosken, 2013; Garmon, 2017; Slade, 2021; Panhans and Taragin, 2022).

2 Model of Price Leadership

We formalize the supply-side of the MSW price leadership model in this section. We depart from MSW only in assuming that demand and cost conditions do not change over time, which simplifies the notation and analysis. We then use a numerical example, under the special case of logit demand, to illustrate the properties of the model, including how price leadership selects among potential collusive equilibria and how incentive compatibility constraints affect outcomes in the model.

2.1 Price Leadership Structure

Let there be a set $\mathbb{F}$ of firms indexed by $f = 1, \ldots, F$ and a set $\mathbb{J}$ of products indexed by $j = 0, \ldots, J$. Each firm sells a subset $\mathbb{J}_f$ of the available products. Time periods are discrete and a timing parameter, $\delta \in (0, 1)$, plays the role of a discount factor. However, its value encompasses more than just the patience of firms, a matter that we discuss in greater detail below. Without loss of generality, we label firm 1 the *leader*. Firms are separated into two groups, a pricing coalition that includes the leader and at least one other firm, and a fringe comprising all firms not contained in the coalition. We collect the coalition firms in the set $\mathbb{C}$, such that the firm f is in the coalition if $f \in \mathbb{C}$. All product characteristics and production costs are common knowledge.

In each time period, play proceeds as follows:

1. The leader announces a supermarkup, $m \geq 0$, to all firms.

2. All firms (including the leader) set prices simultaneously and receive payoffs given by the profit function $\pi_f(\mathbf{p})$, where $\mathbf{p}$ is the vector of prices.

MSW examine a *price leadership equilibrium* (PLE) in which all coalition firms set prices in the second stage that equal static Nash-Bertrand prices plus the supermarkup, so long as there has been no prior deviation from that practice. The supermarkup is cheap talk that affects firm beliefs and thus guides the prices that obtain in the second stage. In the PLE, fringe firms maximize their profit function given the prices of other firms, and taking into account the supermarkup.

The profit function of each firm f is given by

$$\pi_f(\mathbf{p}) = \sum_{j \in \mathbb{J}_f} (p_j - c_j) s_j(\mathbf{p}) M, \tag{1}$$

where c_j is the marginal cost of product j, $s_j(\cdot)$ is a demand function that characterizes the fraction of consumers that purchase product j, given any vector of prices, and, M is the total number of consumers. The realized value of the demand function differs from what would typically be treated as an antitrust market share, for reasons that we explain later. Any fixed costs are excluded from the model because they do not affect pricing decisions.

Static Nash-Bertrand prices obtain if every firm maximizes its profit function given the prices of other firms. We denote the Nash-Bertrand prices and the associated profits as $\mathbf{p}^B$ and π_f^B for all f, respectively. If instead the coalition firms adopt the supermarkup m, their prices are given by $p_j^{PL} = p_j^B + m$. We denote the resulting vector of prices (including entries for both coalition and fringe firms' products) by $\mathbf{p}^{PL}(m)$ and the associated profits by $\pi_f^{PL}(m)$ for all f.

Any deviations from the prices in $\mathbf{p}^{PL}(m)$ by a coalition firm are punished with reversion to Nash-Bertrand equilibrium forevermore.[6] Thus, the coalition firms employ Grim Trigger strategies. At first blush, this may appear to be a strong assumption, and in many applications it may be difficult to ascertain how punishment would occur in the event of a deviation. Furthermore, a period defines the length of time over which a firm earns deviation

[6]Deviations by a fringe firm are not punished, but also would not be profitable.

profit before punishment, and it might not be clear in practice whether this corresponds to a month, year, or something else. However, the interpretation of δ as a timing parameter, not just a discount factor, weakens these assumptions substantially. Our model ends up being equivalent to alternatives with finite punishment or with different durations of deviation profit, provided the timing parameter is treated as summarizing both the patience of firms and the timing of the game.[7] The main purpose of the Grim Trigger formulation is for notational tractability.

Firms in the coalition believe that the supermarkup will be adopted in the second stage if the present value of adoption weakly exceeds the present value of deviation for all coalition firms. This is the case if $g_f(m) \geq 0$ for all $f \in \mathbb{C}$, where

$$g_f(m) = \underbrace{\pi_f^{PL}(m) - \pi_f^{D}(m)}_{\text{(negative) current foregone profits if do not deviate}} + \underbrace{\frac{\delta}{1-\delta}\left(\pi_f^{PL}(m) - \pi_f^{B}\right)}_{\text{future additional profits if do not deviate}}. \tag{2}$$

We refer to $g_f(m)$ as the *slack function* of firm f. In this expression, $\pi_f^D(m)$ is the profit obtained by deviating. Any firm that deviates selects prices that maximize their profit function given that other firms' prices are fixed at their values in $\mathbf{p}^{PL}(m)$.[8] As demand and cost conditions are common knowledge, if $g_f(m) < 0$ for any $f \in \mathbb{C}$ then all firms believe that a deviation will occur, and this too is common knowledge, so play collapses to Nash-Bertrand immediately.

In considering its announcement of the supermarkup, the leader assesses its profit function and the supermarkups to which the coalition $\mathbb{C}$ would adhere. The leader selects the supermarkup to solve the following constrained maximization problem:

$$\max_{m \geq 0} \quad \pi_1^{PL}(m) \quad \text{s.t. } g_f(m) \geq 0, \ \forall f \in \mathbb{C}, \tag{3}$$

conditional on the coalition $\mathbb{C}$. Thus, the slack functions characterize the IC constraints of the coalition firms. Under mild regularity conditions, there is always some positive supermarkup that increases the profit of the leader above its Nash-Bertrand level and does not violate incentive compatibility. Therefore, deviations do not occur along the equilibrium path. The

[7] This equivalence is recognized in Rotemberg and Saloner (1986), which argues that infinite punishment with a low discount factor is isomorphic to finite punishment with a high discount factor. Formal proofs are provided in the Appendix of MSW.

[8] Equation (2) highlights that in our version of the price leadership model the profit functions do not change over time. MSW discusses the challenges of allowing for time-varying profit functions given that data are inevitably finite, and takes one approach to partially incorporate some inter-temporal changes.

solution to the leader's maximization problem may or may not be constrained by the IC constraints. We refer to these scenarios as being associated with the constrained PLE and unconstrained PLE, respectively.

2.2 Graphical Illustration

We now present a graphical illustration of the model to help build intuition. For this example, we assume that demand follows a multinomial logit. The fraction of consumers that purchase product j is given by

$$s_j(\mathbf{p}) = \frac{\exp(\beta_j - \alpha p_j)}{\sum_{j \in \mathbb{J}} \exp(\beta_j - \alpha p_j)}, \tag{4}$$

where β_j is the "quality" of product j and α is the price coefficient for all products. This formulation incorporates an "outside good" that is not owned by any of the firms. We index the outside good as $j = 0$ and normalize its quality and price to zero. We assume that there are three single-product firms. Their qualities are $\beta_1 = \beta_2 = 3$ and $\beta_3 = 1$, and their costs are $mc_1 = mc_2 = 0$ and $mc_3 = 1.25$. Thus, the first two firms have higher qualities and lower costs than the third firm. We assume a price parameter of $\alpha = 1.5$. All three firms are in the coalition.

Figure 1 shows how price leadership selects among the many possible collusive outcomes that may constitute SPE under the folk theorems. This figure depicts the reaction functions of firms 1 and 2, which are identical. To start, the Nash-Bertrand equilibrium is identifiable as the intersection of these reaction functions. Any collusive equilibrium featuring prices above Bertrand levels would be in the northeast region from that intersection. However, under price leadership, the leader considers only symmetric price increases above the Nash-Bertrand equilibrium, which we represent as the dotted 45-degree line. Furthermore, under price leadership, the leader selects where along this line prices will fall. If the timing parameter is sufficiently close to one then the unconstrained PLE is selected. Otherwise, a constrained PLE is selected; the one that we show in the figure corresponds to $\delta = 0.40$. Regardless, the structure of the model collapses a myriad of possible SPE to a unique solution.

Extending the illustrative example, Figure 2 plots the slack functions that arise with $\delta = 0.40$ for the leader (Panel A) and for firm 3, the smaller coalition member (Panel B). The slack functions are positive for small supermarkups, and negative for larger supermarkups. That is, the present value of price leadership exceeds the present value of deviation for lower price elevations, but this flips as prices increase. The slack function of firm 3 crosses zero at $m = 0.56$, marked in both panels by the vertical blue line. As the slack function for the

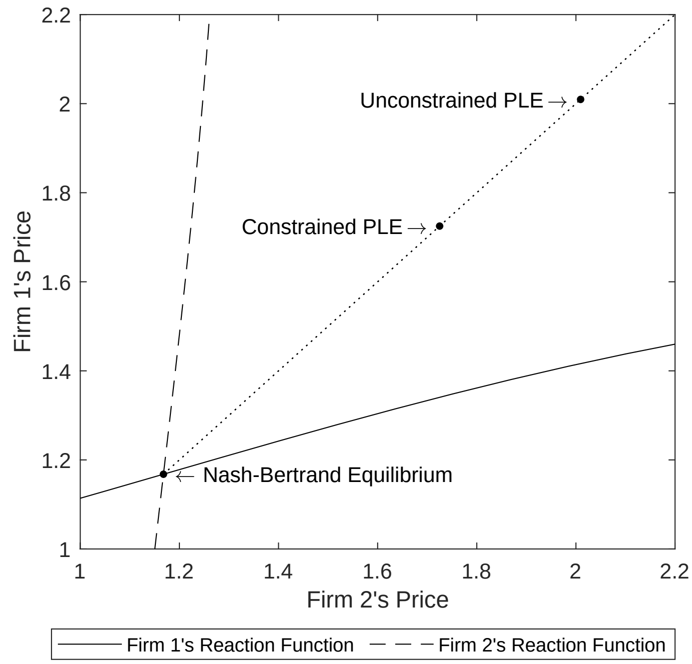


Figure 1: Illustration of the Price Leadership Equilibrium

other firms is positive at this point, it is firm 3 that constrains equilibrium prices. The higher supermarkups preferred by the leader would not be accepted because the smaller coalition member would deviate. Being the higher cost, lower quality producer, firm 3 loses sales at a high relative rate as prices rise across all products in the market. As a result, firm 3 wishes to deviate sooner when the supermarkup increases. Recognizing this, the leader chooses the supermarkup where firm 3's slack function just crosses zero.

Finally, we consider the unconstrained PLE in greater detail. With logit demand and single-product firms, it can be shown that if all firms price in Nash-Bertrand equilibrium then the following first order conditions obtain:

$$p_f - c_f = \frac{1}{\alpha(1 - s_f(\mathbf{p}))}$$

for all $f \in \mathbb{F}$. For comparison, in an unconstrained PLE, the leader's first order condition is

$$p_1^B + m - c_1 = \frac{1}{\alpha(1 - \sum_{f \in \mathbb{C}} s_f(\mathbf{p}^{PL}(m)))}.$$

In the Nash-Bertrand first order conditions, the firm sets price to balance its desire for an

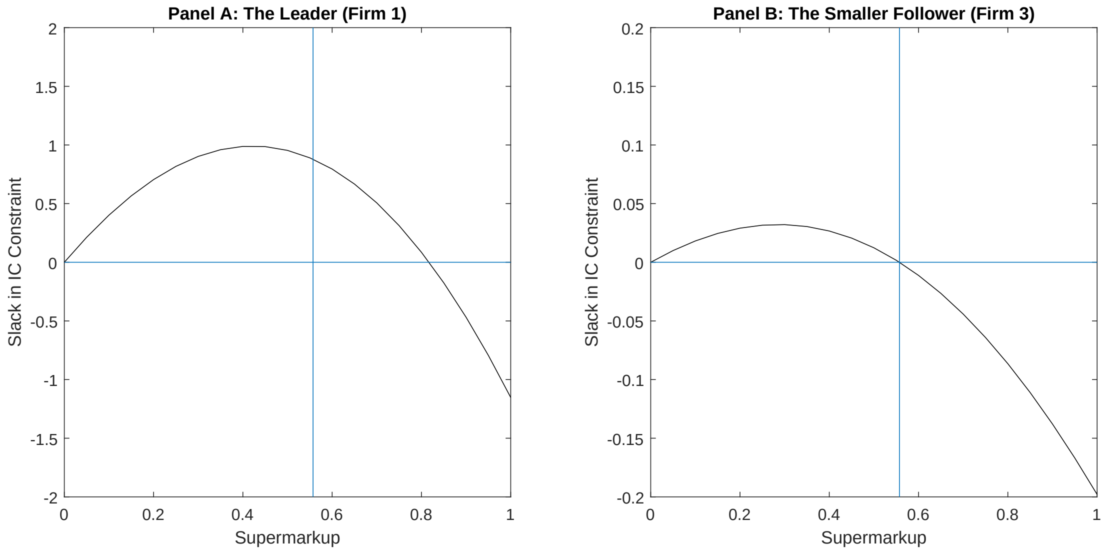


Figure 2: Slack Functions in the Numerical Illustration

Notes: The figure provides the slack functions for the leader (Panel A) and one of the other coalition members (Panel B) with supermarkups $m \in [0, 1]$. Incentive compatibility is satisfied for supermarkup m if the slack functions are positive (i.e., above the horizontal blue line). The vertical blue line shows the equilibrium supermarkup of 0.56, with $\delta = 0.40$.

increased profit margin against the consumer propensity to substitute away in response to higher prices, as measured by the price coefficient α times $(1 - s_f)$.[9] The unconstrained first order condition for the price leadership problem has the same form, except the leader accounts for substitution outside the entire coalition, as reflected by α times $(1 - \sum_f s_f)$, rather than only substitution from its own product. In this way, the leader's problem captures coordinated interactions with other firms.

3 Calibration of the Model

In this section we discuss how our price leadership model can be calibrated with a small set of data. Unlike in a number of academic research settings (such as in MSW) where large panels of sales data are available, antitrust agencies often only have access to a small cross-section of prices and market shares. It is usually not possible to estimate a highly flexible demand system from such limited information, which is why we and many other merger simulation frameworks rely on simple functional forms like the logit. However, antitrust authorities often do have access to confidential data on marginal costs, which we can leverage to separately

[9]The logit own-price elasticity is given by $-\alpha(1 - s_f)p_f$.

identify the supermarkup.

3.1 Logit Demand

Overview We begin with the logit demand system defined in equation (4). We assume that the inside goods constitute a relevant antitrust market, and that the outside good represents products that are outside of the market.[10] Logit demand can be a reasonable approximation to richer demand systems when products in the market are highly similar to each other because, in that case, market shares can be a good indicator of customer substitution patterns. As explained in Miller and Sheu (2021), this situation is likely to arise in a number of antitrust contexts where markets are narrowly defined so that market shares and concentration measures are meaningful.

The objects to be recovered are the qualities and costs of the products, $\{\beta_j\}_{j\in\mathbb{J}}$ and $\{c_j\}_{j\in\mathbb{J}}$, and the price parameter, α. There are a variety of methods and data sources that can be used in calibration. However, we will assume a reasonably standard case in which the available data are as follows:

1. The market shares of each product. In antitrust analyses, shares are defined *within* the market, and so differ from the choice probabilities in equation (4). Letting x_j be the market share of product j, we have $x_j = s_j/(1-s_0)$.

2. The prices of each product.

3. The marginal costs of two products (equivalently, the margins of two products). One product is in the coalition; the other is in the fringe.

4. A diversion ratio between two products, where diversion from product k to product j is defined as $div_{k\to j} = -(\partial s_j/\partial p_k)/(\partial s_k/\partial p_k)$.[11]

Relative to a standard calibration of a model with Nash-Bertrand competition and logit demand, this list differs in that *two* costs or margins are included, rather than one.

[10] The United States *Horizontal Merger Guidelines* define a relevant antitrust market as a set of products over which a hypothetical monopolist would impose at least a small and significant non-transitory increase in price. An alternative assumption that could be applied here is that the inside goods constitute a candidate antitrust market. In that case, the model could be calibrated and then simulated to examine the prices that a hypothetical monopolist may impose.

[11] Note that this diversion ratio accounts for substitution outside of the market and is thus different from diversion calculated according to market shares among the inside goods.

Calibration can proceed without information on diversion if an assumption is made on the choice probability of the outside good, s_0.[12] However, given that the logit model implies diversion in proportion to choice probabilities, assuming s_0 pins down the degree of substitution between the inside goods and the outside good, which can possibly result in unrealistic substitution patterns. We prefer to rely on data to inform these patterns, when such data are available. Our base case uses information on diversion as our data source. Alternatively, one could instead use data on the market elasticity of demand, as we explain further below.

Calibration of demand parameters Given the way in which market shares are defined, we have

$$s_j = x_j(1 - s_0) \tag{5}$$

for all $j \in \mathbb{J} \setminus \{0\}$. Therefore, if we recover s_0, we can immediately identify the other choice probabilities from observed market shares. For this purpose, we rely on the diversion ratio. The diversion ratio from product k to product j is the number of consumers that switch from k to j in response to a marginal increase in the price of k, divided by the total number of consumers that leave k due to the same price increase.[13] With logit, this diversion ratio is given by

$$div_{k \to j} = \frac{s_j}{1 - s_k}. \tag{6}$$

Substituting in using equation (5), the choice probability of the outside good is then

$$s_0 = \frac{div_{k \to j} \times (x_k - 1) + x_j}{div_{k \to j} \times x_k + x_j}, \tag{7}$$

which is a function only of data we observe. Once we have thus recovered s_0, equation (5) identifies $\{s_j\}_{j \in \mathbb{J}, j \neq 0}$.

Fringe firms maximize static profit and, given logit demand, their prices can be shown to satisfy the following first order condition:

$$p_k - c_k = \frac{1}{\alpha(1 - \sum_{j \in \mathbb{J}_{g(k)}} s_j(\mathbf{p}))}, \tag{8}$$

where product k is sold by fringe firm $g(k)$. We use the equation that corresponds to the

[12] Equivalently one could make an assumption on the total number of consumers (M), which is often referred to in the literature as the "market size."

[13] Conlon and Mortimer (2021) show that diversion ratios can be obtained using any marginal change in a product's attractiveness to consumers. In the context of the logit model, changes in product quality give rise to the same diversion ratios as changes in price.

fringe product for which there are cost data available. Given that we now have knowledge of the choice probabilities, equation (8) can be solved for α.

We could also obtain s_0 and α with an alternative strategy using the market elasticity. By the definition of the market elasticity and the properties of logit demand, we have

$$\epsilon \equiv -\left(\sum_{j\in\mathbb{J},j\neq 0} \frac{\partial s_j(\mathbf{p})}{\partial p_j}\right) \frac{\overline{p}}{\sum_{j\in\mathbb{J},j\neq 0} s_j(\mathbf{p})} = \alpha s_0 \overline{p}, \tag{9}$$

where $\overline{p}$ is the weighted average price among the inside products. This relationship, combined with equations (5) and (8), form a system that can be jointly solved for $(\{s_j\}_{j\in\mathbb{J}}), \alpha)$. Intuitively, the choice probability of the outside good, s_0, scales with the market elasticity and therefore allows the model to capture substitution patterns suggested by the data. In this way, the model provides the flexibility of a one-level nested logit model in which the inside goods are in one nest and the outside good is in another. Our formulation, however, is mathematically more tractable.[14]

With the price parameter and the choice probabilities in hand, the remaining demand parameters $\{\beta_j\}_{j\in\mathbb{J}}$ can be recovered using the Berry (1994) inversion:

$$\ln(s_j) - \ln(s_0) = \beta_j - \alpha p_j \tag{10}$$

for all $j \in \mathbb{J}$. Note that the discussion thus far has not involved the supermarkup. Observing marginal cost for a fringe product allows us to identify the demand parameters solely from static price setting among non-coalition firms.[15]

Calibration of the supply-side Turning to the supply side, we need to recover the supermarkup, the remaining unknown marginal costs, and the timing parameter. As the price coefficient and the choice probabilities have been recovered, and prices are data, equation (8) also obtains the marginal costs for all fringe products. Then, fix the supermarkup at a candidate value $\hat{m}$. The Nash-Bertrand coalition prices that would have prevailed in the absence of price leadership can be recovered by subtracting $\hat{m}$ from the observed coalition prices. The Nash-Bertrand prices for products outside the coalition can be recovered using

[14] An alternative approach at this stage is to use *two* data points on fringe firms' cost to replace the market elasticity (Sheu and Taragin (2012)). To avoid collinearity in the system of equations, the two costs must apply to different firms. A third data point on cost—for a coalition firm—would be necessary later in the calibration procedure.

[15] If one does not observe a marginal cost for a fringe product, the calibration routine is poorly identified, because it will have difficulty distinguishing between the supermarkup and how price sensitive consumers are.

equation (8), holding coalition prices fixed at their Nash-Bertrand values implied by the supermarkup $\hat{m}$. The resulting vector of prices, $\mathbf{p}^B(\hat{m})$, can be combined with equation (4) to derive the associated Nash-Bertrand choice probabilities. Plugging these prices and choice probabilities into equation (8) implies the margins associated with $\hat{m}$, which we can compare to the margin we observe for one coalition product and thereby recover the supermarkup. Once m has been found, the remaining marginal costs for other coalition products follow by again applying equation (8) to the implied Bertrand prices for these products.

When combined with assumptions on the structure of demand and information on prices, cost data for the coalition help to identify the supermarkup. Intuitively speaking, if one has recovered the parameters of the demand curve and also knows firms' marginal costs, this information immediately implies what prices would be in a Nash-Bertrand setting. In so far as those implied Nash-Bertrand prices are lower than observed prices, the difference can be attributed to the supermarkup. In the case of logit demand, we know that the margin, in levels, in a Nash-Bertrand setting is a simple function of the price coefficient α and choice probabilities. Once the parameter α is pinned down by the margin of one fringe product, it along with observed shares and s_0 immediately imply what the margin for any other product should be in a Nash-Bertrand framework. If margins are higher, then this indicates behavior that departs from typical static price-setting. This discussion also makes it clear why we require marginal cost information for a product in the coalition. Otherwise, the calibration cannot distinguish between a case where coalition firms have high unit costs versus a case where there is a high supermarkup.

All that remains is the timing parameter. If data are to inform its magnitude, then it must be the case that the leader is constrained in its choice of the supermarkup—an IC constraint must bind. This is testable, as one can simulate the unconstrained supermarkup using objects already obtained and compare it with the calibrated supermarkups. In a constrained PLE, the timing parameter is pinned down by the slack functions of equation (2). Namely, with the demand parameters and the marginal costs, it is possible to compute the profit objects, $\pi_f^{PL}(m)$, $\pi_f^{D}(m)$, and π_f^{B} for all $f \in \mathbb{C}$. Then it can be determined which coalition firm has the slack function that is closest to binding, and δ can be selected to set its slack function equal to zero.

3.2 Nested Logit Demand

Overview We now discuss calibration with a two-level nested demand model. We assume there are two groups of products, one with all the inside goods and the other with the outside good. Within the group that contains the inside goods, there are additional subgroups. The presence of subgroups allows for more flexible substitution patterns among the products that are in the market, relative to the logit model presented in the previous section.

Formally, let the products be partitioned into two groups, $g = 0, 1$. The outside good, $j = 0$, is the only member of group 0. Further let group 1 be partitioned into H_g subgroups, $h = 1, \ldots H_g$. Denote the set of subgroups $\mathbb{H}$ and the set of products in subgroup h as $\mathbb{J}^h$. The choice probability of product $j \in \mathbb{J}^h$ is given by

$$s_j(\mathbf{p}) = \overline{s}_{j|hg}(\mathbf{p})\overline{s}_{h|g}(\mathbf{p})\overline{s}_g(\mathbf{p}), \tag{11}$$

where $\overline{s}_{j|hg}(\mathbf{p})$ is choice probability of product j conditional on its subgroup (and group) being selected, $\overline{s}_{h|g}(\mathbf{p})$ is the choice probability of product j's subgroup conditional on its group being selected, and $\overline{s}_g(\mathbf{p})$ is the choice probability of its group. With the following inclusive values

$$\begin{aligned} I_{hg} &= (1-\sigma_1)\ln \sum_{k\in\mathbb{J}^h} \exp\left(\frac{\beta_k - \alpha p_k}{1-\sigma_1}\right) && (12) \\ I_g &= (1-\sigma_2)\ln \sum_{h\in\mathbb{H}} \exp\left(\frac{I_{hg}}{1-\sigma_2}\right) && (13) \\ I &= \ln(1+\exp(I_g)), && (14) \end{aligned}$$

we obtain expressions for the choice probabilities:

$$\overline{s}_{j|hg} = \frac{\exp\left(\frac{\beta_j - \alpha p_j}{1-\sigma_1}\right)}{\exp\left(\frac{I_{hg}}{1-\sigma_1}\right)} \quad , \quad \overline{s}_{h|g} = \frac{\exp\left(\frac{I_{hg}}{1-\sigma_2}\right)}{\exp\left(\frac{I_g}{1-\sigma_2}\right)} \quad , \quad \overline{s}_g = \frac{\exp(I_g)}{\exp(I)}. \tag{15}$$

The demand parameters are the product qualities, $\{\beta_j\}_{j\in\mathbb{J}}$, the price parameter, α, and two nesting parameters, σ_1 and σ_2.

The model is consistent with random utility maximization if $1 \geq \sigma_1 \geq \sigma_2 \geq 0$. The parameter σ_1 captures the correlation of utilities that consumers experience among products in the same subgroup, and the parameter σ_2 captures the same concept for the groups. The model collapses to a one-level nested logit with groups as nests if $\sigma_1 = \sigma_2$. The model collapses to a one-level nested logit with sub-groups as nests if $\sigma_2 = 0$.

Calibration can proceed along the lines of what we have described for logit demand. Again, there are a variety of methods and data sources that can be used. We focus on a case with the following data:

1. The market shares of each product.
2. The prices of each product.
3. The marginal costs of two products (equivalently, the margins of two products). One product is in the coalition; the other is in the fringe.
4. Two diversion ratios.
5. An assumption on the choice probability of the outside good.

Compared to the flat logit model, here the assumption on the outside good choice probability is less important, provided a large enough number is selected, because the nesting parameter σ_2 also governs substitution between the inside products and outside good. That is, the value for σ_2 can be calibrated to fit the data on diversions given that s_0 is not so small as to swamp the impact of the nesting parameter. An implication of a known (assumed) value of s_0 is that the unconditional and conditional choice probabilities of the inside products can be calculated from market shares. Therefore, given items 1 and 5, the choice probabilities are data.

Calibration If products k and j are in the same subgroup h then the diversion ratio that characterizes substitution from k to j is given by

$$div_{k\to j} = \frac{s_j(1-\sigma_1)(1-\sigma_2) + \overline{s}_{j|hg}\overline{s}_{h|g}\sigma_2(1-\sigma_1) + \overline{s}_{j|hg}(\sigma_1-\sigma_2)}{(1-\sigma_2) - s_k(1-\sigma_1)(1-\sigma_2) - \overline{s}_{k|hg}\overline{s}_{h|g}\sigma_2(1-\sigma_1) - \overline{s}_{k|hg}(\sigma_1-\sigma_2)}. \tag{16}$$

If instead products k and j are in different subgroups then the diversion ratio is

$$div_{k\to j} = \frac{s_j(1-\sigma_1)(1-\sigma_2) + \overline{s}_{j|h(j)g}\overline{s}_{h(j)|g}\sigma_2(1-\sigma_1)}{(1-\sigma_2) - s_k(1-\sigma_1)(1-\sigma_2) - \overline{s}_{k|h(k)g}\overline{s}_{h(k)|g}\sigma_2(1-\sigma_1) - \overline{s}_{k|h(k)g}(\sigma_1-\sigma_2)}, \tag{17}$$

where we use $h(k)$ and $h(j)$ to denote the subgroups of the two products, respectively. The diversion ratio from product k to the outside good is

$$div_{k\to 0} = \frac{s_0(1-\sigma_1)(1-\sigma_2)}{(1-\sigma_2) - s_k(1-\sigma_1)(1-\sigma_2) - \overline{s}_{k|hg}\overline{s}_{h|g}\sigma_2(1-\sigma_1) - \overline{s}_{k|hg}(\sigma_1-\sigma_2)}. \tag{18}$$

The first order condition that characterizes the profit-maximizing price for product k is given by

$$p_k - c_k = \frac{1-\sigma_1}{\alpha} + (1-\sigma_1)\sum_{j \in \mathbb{J}_f}(p_j - c_j)s_j + \frac{(1-\sigma_1)\sigma_2}{1-\sigma_2}\sum_{j \in \mathbb{J}_f \cap \mathbb{J}^{g(k)}}(p_j - c_j)s_{j|hg}s_{h(j)|g} + \frac{\sigma_1 - \sigma_2}{1-\sigma_2}\sum_{j \in \mathbb{J}_f \cap \mathbb{J}^{h(k)}}(p_j - c_j)s_{j|hg}, \quad (19)$$

and if the firm that sells product k has all its products in the same subgroup then this simplifies to

$$p_k - c_k = \frac{1-\sigma_1}{\alpha\left(1 - (1-\sigma_1)\sum_{j \in \mathbb{J}_f} s_j - \frac{(1-\sigma_1)\sigma_2}{1-\sigma_2}\sum_{j \in \mathbb{J}_f} s_{j|hg}s_{h(j)|g} - \frac{\sigma_1-\sigma_2}{1-\sigma_2}\sum_{j \in \mathbb{J}_f} s_{j|hg}\right)}. \quad (20)$$

Depending on the data available, some combination of equations (16)-(20) can be solved for the demand parameters $(\alpha, \sigma_1, \sigma_2)$.[16] For example, if we have data on the margin for a fringe firm only selling in one subgroup, along with diversion between two inside products in the same subgroup, and between two inside products in different subgroups, we would use equations (16), (17), and (20).[17] With $(\alpha, \sigma_1, \sigma_2)$ in hand, the Berry (1994) inversion then can be used to recover $\{\beta_j\}_{j \in \mathbb{J}}$,

$$\ln(s_j) - \ln(s_0) = \beta_j - \alpha p_j + \sigma_1 \ln(\overline{s}_{j|hg}) + \sigma_2 \ln(\overline{s}_{h|g}). \quad (21)$$

As for the supply side, calibration of the unobserved cost terms and the supermarkup proceeds exactly as in the logit case, albeit with the nested logit first order conditions. That is, for a given $\hat{m}$, we can find the implied Nash-Bertrand prices $\mathbf{p}^B(\hat{m})$ and choice probabilities. Plugging these into the expression in (19) evaluated for firm f, whose marginal costs we observe, obtains the supermarkup. The timing parameter can also be recovered as in the logit case.

[16] Alternatively, one could substitute data on the market elasticity in order to recover α from equation (9).

[17] If we instead observe the margin for a fringe firm selling in multiple subgroups, we would use equation (19) evaluated for each of these subgroups. We would need to jointly identify the margins for the subgroups we do not have data from.

Table 1: Data Used in Calibration Example

Firm	Subgroup	In Coalition?	Price	Share	Cost
ABI	Domestic	Yes	9.11	0.444	3.61
SABMiller	Domestic	Yes	8.38	0.258	3.93
Molson Coors	Domestic	Yes	8.82	0.138	4.81
Grupo Modelo	Foreign	No	14.87	0.100	11.41
Heineken	Foreign	No	14.41	0.060	11.46
Domestic to Foreign Diversion					0.107
Market Elasticity					0.500
Outside Share					0.500

Notes: The price, share, diversion, and elasticity are for year 2007 from MSW. The costs shown are calculated during an initial calibration step in order to be consistent with our nesting structure. “ABI” is Anheuser-Busch Inbev.

3.3 Calibration Example from the Beer Market

In order to provide a concrete example of how calibration works, this section applies the methods discussed above to the United States beer industry. We show that despite the simplifications we have made to the demand side, we can obtain merger simulation results comparable to those in MSW. Please refer to that paper for more detail on the beer market.

In this example, the coalition members are Anheuser-Busch Inbev, SABMiller, and Molson Coors, and the fringe competitors are Grupo Modelo and Heineken. We specify a two-level nested logit with all brewers in one group and the outside option in a second group. The group containing all brewers has two subgroups with domestic brewers in one and imports in the other. Prices, shares, the market elasticity, and the diversion to fringe suppliers for year 2007 come from MSW and are shown in Table 1. Rather than using the marginal costs estimated in MSW, which are based on a random coefficients demand system, we calculate costs that are consistent with our nesting structure, and use them as inputs to our calibration procedure. This is accomplished by performing an initial calibration step using the costs estimated by MSW as a starting point. The parameters obtained in this first step are then used to impute costs that are consistent with our model. These costs appear in Table 1.[18]

The results of our calibration procedure are shown in Table 2. The supermarkup and timing parameter align reasonably closely with the values obtained in MSW; their preferred

[18] These results differ from the MSW costs due to the fact that our calibration procedure is over-identified; only two costs are required, but five costs are used.

Table 2: Calibrated Parameter Values

Quality, β_j	ABI	0.701
	SABMiller	0.491
	Molson Coors	0.381
	Grupo Modelo	0.645
	Heineken	0.471
Price Parameter, α		0.102
Subgroup Nesting Parameter, σ_1		0.751
Group Nesting Parameter, σ_2		0.586
Supermarkup, m		1.201
Timing Parameter, δ		0.212

Notes: "ABI" is Anheuser-Busch Inbev.

model results in a supermarkup of 1.20 and a timing parameter of 0.26. Our calibrated values for these parameters are 1.20 and 0.21, respectively. We find that Molson Coors's IC constraint is binding in equilibrium, which also matches the results in MSW.

Lastly, we use our calibration results to simulate a merger between Miller and Coors into MillerCoors, as is also done in MSW. Our results are shown in Table 3, and we find that, assuming there are no marginal cost efficiencies from the merger, the supermarkup increases from 1.20 to 1.72, a difference of 0.52. MSW calculate a 0.39 increase in the supermarkup without efficiencies. We also find, like in MSW, that the supermarkup increases by more when efficiencies are introduced. Finally, both us and MSW find that the IC constraint of MillerCoors is binding after the merger. Our results demonstrate that the calibration routine described in this paper can be used along with limited data to obtain results that closely align with those from the large dataset approach used in MSW.

4 Implications for Competition Policy

This section analyzes the antitrust implications of horizontal mergers in industries characterized by price leadership. We contrast how market outcomes depend on market structure under price leadership versus under static Nash-Bertrand equilibrium. We then examine mergers in industries with price leadership, the pass-through of merger-specific efficiencies, and the consequences of divestitures in mergers of multi-product firms.

Market Structure and Monopoly Outcomes We first study how prices change

Table 3: MillerCoors Merger Counterfactual Results

		Baseline	Merger	Merger with Efficiencies
Supermarkup		1.20	1.72	1.83
ICC Slack	ABI	2.04×10^{-2}	9.18×10^{-3}	6.00×10^{-3}
	SABMiller	6.70×10^{-3}		
	Molson Coors	1.13×10^{-5}		
	MillerCoors		3.05×10^{-4}	9.32×10^{-5}

Notes: "ABI" is Anheuser-Busch Inbev. In the merger with efficiencies, MillerCoors is given the same cost as ABI after the merger.

when firms play a price leadership equilibrium and as an industry converges to monopoly. This exercise provides some baseline intuition for how mergers under price leadership may impact prices. We contrast the resulting prices with those given by static Nash-Bertrand equilibrium. In setting up the numerical exercise, we posit 100 differentiated products with identical costs that are each initially owned by an independent firm. All firms are assumed to be in the coalition. Holding demand for the 100 products and their marginal costs fixed, we then lower the number of firms and recompute the symmetric equilibrium where each firm owns the same number of products. That is, if N is the number of firms, we compute equilibrium for $N \in \{100, 50, 25, 20, 10, 5, 4, 2, \text{and } 1\}$.

Figure 3 plots the resulting equilibrium prices as a function of the Herfindahl-Hirschman Index (HHI), measured on a scale from 0 to $10,000$. We use four different values of the timing parameter δ. Even at 0.2, the lowest δ we consider, we find that prices are higher with price leadership than under Nash-Bertrand by nearly 10 percent when the HHI is near zero. For each value of δ, prices approach the monopoly outcome more rapidly under price leadership than under Nash-Bertrand. For example, when $\delta = 0.7$ even with 10 symmetric firms prices are about 90 percent of the monopoly price, and are actually equal to the monopoly price with 5 symmetric firms. Thus, although this is a stylized exercise, we find that price leadership coordination can sustain relatively higher prices and approaches monopoly pricing faster as markets become more concentrated than under Nash-Bertrand.

IC Constraints and Mergers We now turn to directly studying the price effects of mergers. How a merger changes prices under price leadership is more complex than under Nash-Bertrand. This is because the impact depends on the roles of each merging firm in the coalition structure. We highlight the importance of whether the pair of merging firms includes a coalition member whose IC constraint binds.

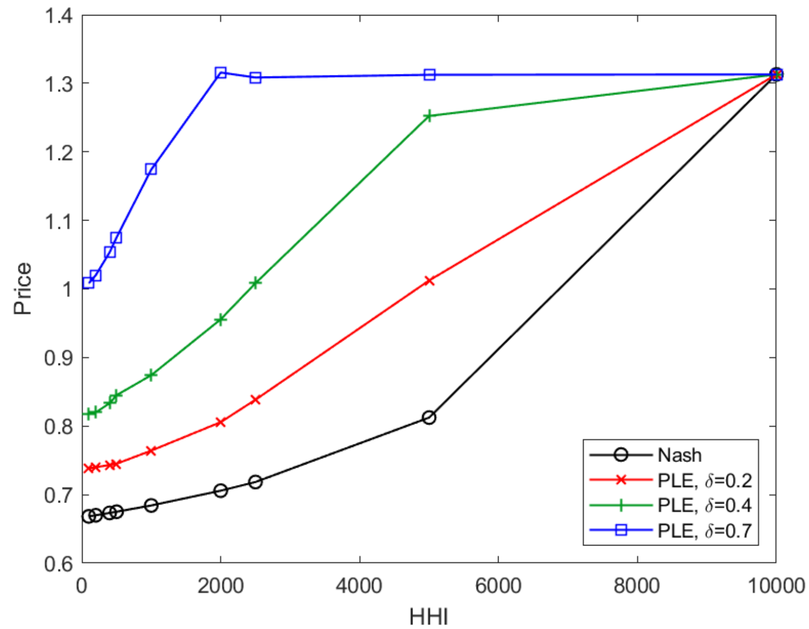


Figure 3: Market Structure and Prices

As an example, we consider a six-firm industry where three firms are in the coalition and three firms are in the fringe. Consumers view the coalition members' products as being in a different nest than those of the fringe. Table 4 shows the parameter values for our numerical experiments and the outcomes in the baseline price leadership equilibrium. The leader, firm 1, has the highest market share as it has relatively high quality and low cost. Firm 3 has relatively high cost and, relatedly, the highest Nash-Bertrand prices. As a result, the nested logit demand structure implies that demand for firm 3's product is most sensitive to a price increase, making it the firm with the binding IC constraint.

Table 5 shows how the equilibrium shifts with different mergers. The first column reproduces the baseline results. The second column shows the results of a merger between firms 1 and 3, two coalition firms where one, firm 3, has the binding IC constraint. Despite firm 3 having only a 6 percent pre-merger market share, this merger results in non-trivial price increases, primarily via the supermarkup, which rises by 40 percent. The third column of Table 5 shows equilibrium outcomes after a merger between firms 1 and 2. In this case neither merging firm has a binding IC constraint. As a result, this merger leads to no change in the supermarkup and only impacts prices through changing the underlying Nash-Bertrand outcomes. In summary, mergers involving firms with small market shares can result in sizable price increases if they include a firm with a binding IC constraint.

The United States *Horizontal Merger Guidelines* describe a maverick as a firm that

Table 4: Baseline Price Leadership Equilibrium

Firm	Nest	Quality	Marginal Cost	Coalition Member	Price	Share	Binding ICC
1	1	2.00	0.40	Yes	0.99	0.28	
2	1	1.75	0.50	Yes	0.99	0.17	
3	1	1.50	0.70	Yes	1.13	0.06	X
4	2	2.00	1.30	No	1.66	0.07	
5	2	2.00	1.50	No	1.80	0.04	
6	2	2.00	1.70	No	1.97	0.02	

Notes: The price coefficient is equal to $\alpha = -2$, the nested logit parameter is $\sigma = 0.5$, and the timing parameter is $\delta = 0.3$. The outside good has a share of 0.36, variable profit is 0.31, the baseline supermarkup is $m = 0.15$, and consumer surplus (net of a constant) is 0.50.

"plays a disruptive role in the market for the benefit of consumers."[19] One example given is a firm that resists industry norms to cooperate on price setting. Fringe firms can thus be thought of as a type of maverick. When a coalition member and a fringe firm merge, the impact on prices and the underlying mechanism depend on whether the coalition firm's IC constraint binds. In these experiments we allow for the possibility that a different supermarkup will apply for products in the two nests.[20] The fourth column of Table 5 shows equilibrium outcomes after firm 2, a coalition member without a binding constraint, merges with fringe firm 4. The supermarkup for Group 1 increases from 0.15 to only 0.16, and the supermarkup in Group 2 is 0.03. The fifth column of Table 5 shows post-merger outcomes when firm 3, whose pre-merger IC constraint binds, acquires the same fringe firm. The Group 1 supermarkup now increases to 0.21, and the Group 2 supermarkup is 0.02. Consumer welfare goes down by slightly more when firm 3 and firm 4 merge than when firm 2 and firm 4 merge, despite the fact that firm 3's pre-merger market share is less than half of firm 2's share.

Efficiencies and Pass-Through In some cases mergers may result in marginal cost reductions that offset the incentives to raise prices. The pass-through of cost reductions into prices depends on how firms compete with one another. We explore the pass-through of marginal cost reductions under price leadership using a numerical example where we reduce the marginal costs of each of the merged firms' products by varying percentages.

Figures 4a and 4b show post-merger equilibrium prices after firms 1 and 3 merge.

[19] The discussion of mavericks is in §2.1.5.

[20] The supermarkup in Group 2 is set by one of the coalition firms that owns a product in that nest. This is the leader if the leader owns a product in Group 2, or it is another firm if the leader does not. After the Group 2 supermarkup is set, the leader chooses the Group 1 supermarkup.

Table 5: Mergers in PLE

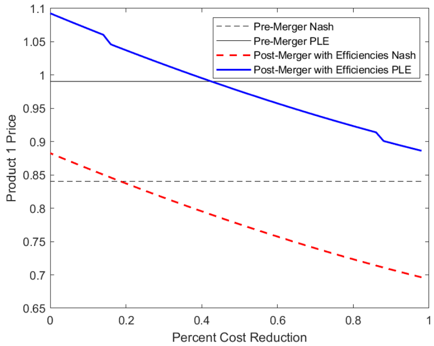
Ownership Structure	1*	1*	1*	1*	1*
	2*	2*	1*	2*	2*
	3*	1*	3*	3*	3*
	4	4	4	2*	3*
	5	5	5	5	5
	6	6	6	6	6
Prices	0.99	1.09	1.16	1.00	1.05
	0.99	1.06	1.26	1.01	1.05
	1.13	1.39	1.15	1.14	1.2
	1.66	1.66	1.66	1.72	1.69
	1.80	1.80	1.80	1.81	1.81
	1.97	1.97	1.97	1.98	1.98
Outside Share, s_0	0.36	0.40	0.43	0.37	0.39
Consumer Surplus	0.50	0.45	0.43	0.49	0.47
Total Profit	0.31	0.34	0.34	0.32	0.33
Group 1 Supermarkup, m_1	0.15	0.21	0.15	0.16	0.21
Group 2 Supermarkup, m_2				0.03	0.02

Notes: Firm's with a * are in the coalition. Firm 3 has the binding ICC in the first and fourth columns. Firm 2 has the binding ICC in the second and fifth columns. Firm 1 has the binding ICC in the third column.

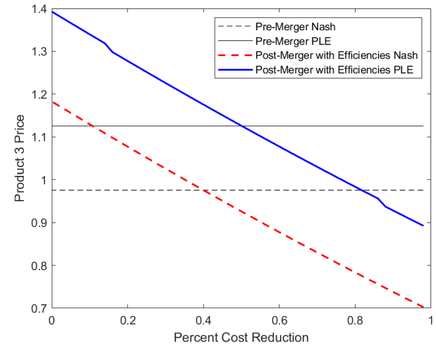
Recall, firm 3's IC constraint binds pre-merger. The figures show that under price leadership, the marginal cost reduction necessary to leave prices unchanged is much larger than what would be necessary under Nash-Bertrand. For product 1, the required cost reduction is around 40 percent under price leadership. This is over 20 percentage points greater than what would be necessary with Nash-Bertrand. The same is true for product 3.

Figures 4c and 4d show the same relationship after the merger of firms 1 and 2, two coalition members with slack in their pre-merger IC constraints. Here, the critical marginal cost reduction is larger under Nash-Bertrand than it is under price leadership. In summary, the critical marginal cost reductions necessary to leave prices unchanged under Nash-Bertrand competition can be a poor predictor of what would be necessary under price leadership. If the firm in the coalition with the binding IC constraint is involved in the merger, larger reductions in marginal costs are needed under price leadership than under Nash-Bertrand competition. However, if the binding coalition member is not involved, critical marginal cost reductions under price leadership may be smaller or larger than the critical marginal cost reductions under Nash-Bertrand competition.

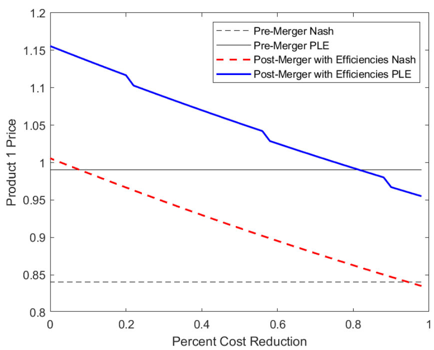
Divestitures A common remedy to mergers deemed to be anti-competitive is to re-



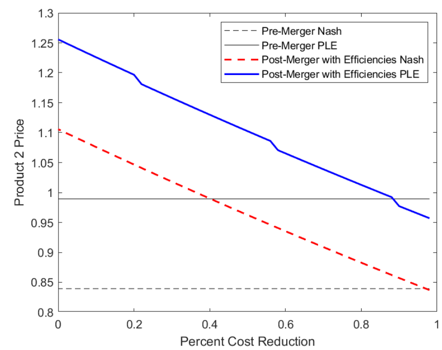
(a) Product 1 after Merger of Firms 1 and 3



(b) Product 3 after Merger of Firms 1 and 3



(c) Product 1 after Merger of Firms 1 and 2



(d) Product 2 after Merger of Firms 1 and 2

Figure 4: Price Changes from Mergers with Varying Marginal Cost Reductions

quire the divestiture of key products or brands to a third party. Here, we explore the effects of divestitures in a scenario where firms are engaged in a price leadership equilibrium. The effects of divestitures under price leadership are more complicated than those under a Nash-Bertrand equilibrium because changing which products are priced in the coalition can have a significant impact on the supermarkup.

Table 6 shows equilibrium supermarkups and welfare for several different ownership structures.[21] The baseline scenario, shown in the leftmost column, reflects a merger between firms 3 and 4, with firms 1, 2, and 3 in the coalition. The second column shows the impact of a merger between firms 1 and 3. Consumer surplus falls and total profit rises. However, this is mostly the result of increases in the Nash-Bertrand prices; the increase in the supermarkup, especially for the products in Group 1, is relatively small due to the fact that firm 2, who is not affected by the merger, has the binding IC constraint in the baseline scenario.

The last two columns in Table 6 show the results of a potential remedy to the effects

[21] All parameters used in this exercise (quality, cost, etc.) are the same as those used earlier in this section.

Table 6: Mergers and Divestitures

	1*	1*	1*	1*
	2*	2*	2*	2*
Ownership	3*	1*	5	5*
Structure	3*	1*	1*	1*
	5	5	5	5*
	6	6	6	6
Consumer Surplus	0.47	0.43	0.50	0.46
Total Profit	0.33	0.35	0.31	0.34
Group 1 Supermarkup, m_1	0.21	0.22	0.15	0.21
Group 2 Supermarkup, m_2	0.02	0.09	0.04	0.07

Notes: Firm's with a * are in the coalition. Firm 2 has the binding IC constraint in the left three columns. Firm 5 has the binding IC constraint in the rightmost column.

of the merger. In both cases, the third product, which is in Group 1, must be divested to firm 5 as a condition of the merger being approved. Firm 1 is still allowed to acquire the fourth product, which is in Group 2. The third column shows that, if firm 5 does not join the coalition, the divestiture completely remedies the impact of the merger; consumer surplus is actually higher than in the baseline scenario and the supermarkup for Group 1 is substantially lower. However, if firm 5 does join the coalition, the divestiture has a lesser impact. As the fourth column shows, while the divestiture is still an improvement on not having any remedy, consumer surplus is still lower than it was pre-merger.

5 Conclusion

Our purpose has been to provide an accessible methodology for simulating the coordinated effects of mergers. Starting from the price leadership model of MSW, we show how a simplified version of the framework can be calibrated with data that are often available to antitrust authorities. By introducing a supermarkup into the typical Nash-Bertrand setup, we demonstrate how the methods that practitioners are already familiar with in the context of unilateral effects simulations can be extended to quantify the impact of collusion. Our numerical results highlight the role that IC constraints play in determining the equilibrium effects of mergers.

It is worth emphasizing that the model we explore here remains somewhat specialized, as coordination need not take the form of price leadership. Therefore, careful consideration should be applied when evaluating the fit of the model to a given empirical setting. Furthermore, the paths to calibration that appear most feasible to us involve a specific set of facts about the market, including that some but not all firms engage in pre-merger coordination. In part because the broad application of our model may not be warranted, we continue to view the modeling of coordinated effects to be a promising area for future research. Adapting recent advancements in the structural empirical literature on cartels and collusion (e.g., Igami and Sugaya, 2021) for use by practitioners, keeping in mind the data and time limitations of merger investigations and litigation, may be particularly helpful to antitrust authorities.

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