

Mergers Facilitate Tacit Collusion: Empirical Evidence from the U.S. Brewing Industry*

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Abstract

We study the mechanisms through which mergers of competitors affect market outcomes. Our focus is on the MillerCoors joint venture, which combined the second and third largest brewers of beer in the United States. We document retail pricing and sales patterns consistent with a negative supply shock contemporaneous with the date of consummation. We then estimate models of demand and price competition and show that emergent tacit collusion between MillerCoors and its largest rival, Anheuser-Busch Inbev, best explains the data. We use counterfactual simulations to decompose the observed price increases into unilateral effects, coordinated effects, and merger-specific efficiencies. Among other results, we find that (i) marginal cost reductions roughly counter-balance changes in unilateral pricing incentives; (ii) consumer surplus loss arises due to post-merger coordination; and (iii) the merger increases total surplus, despite higher retail prices, due to the magnitude of marginal cost reductions.

Keywords: tacit collusion; horizontal mergers; unilateral effects; coordinated effects; merger efficiencies; antitrust policy; merger enforcement; brewing industry
JEL classification: K21; L13; L41; L66

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1 Introduction

Among the longest-standing theoretical results of industrial economics is that collusion arises more readily in concentrated markets than in markets with many competitors (e.g., Stigler (1964); Selten (1973)). While the empirical literature has made steady progress in identifying market power in concentrated markets (e.g., Bresnahan (1987); Gasmi, Laffont and Vuong (1992); Nevo (2001); Knittel and Stango (2003); Ciliberto and Williams (2014); Conlon and Rao (2015)), there is little empirical evidence that increases in concentration facilitate coordination among competitors. The value of research along these lines is heightened by the consideration given to the coordinated effects of mergers by antitrust authorities in the United States and elsewhere.¹

This paper provides empirical evidence that horizontal mergers can soften price competition beyond what can be explained by changes in unilateral pricing incentives.² We focus on MillerCoors, a joint venture between SABMiller PLC and Molson Coors Brewing Company that is fully responsible for the operations of these brewers in the United States and Puerto Rico.³ The joint venture underwent antitrust review as a merger between the second- and third-largest firms in the U.S. brewing industry. The merger was approved on June 5, 2008 by the Department of Justice (DOJ) on the basis that any anticompetitive market effects likely would be outweighed by substantial merger-specific cost reductions. Both academic research and the companies' financial reports confirm that these cost efficiencies have been realized, especially where the combined network of Miller and Coors brewing facilities reduces effective shipping distances (e.g., Ashenfelter, Hosken and Weinberg (2014b)).

We use program evaluation techniques to document changes in market outcomes that are consistent with a negative supply shock contemporaneous with the merger. We find that average retail prices increase by six percent, both for MillerCoors and its closest competitor, Anheuser-Busch Inbev (ABI), while sales volumes decrease. We then estimate a random coefficients logit model (RCLM) and a model of price competition that allows for coordinated

¹The 2010 Horizontal Merger Guidelines promulgated by the U.S. Department of Justice and Federal Trade Commission emphasize that mergers in concentrated markets can lead to tacit collusion through a variety of mechanisms. Recently, a number of high profile merger challenges have alleged coordinated effects (e.g. *United States v. AT&T*, *T-Mobile*, and *Deutsche Telekom* (AT&T/T-Mobile) and *United States v. US Airways Group, Inc. and AMR Corporation* (American/US Airways)).

²Unilateral effects refer to the difference in differentiated product prices between pre- and post-merger static Bertrand equilibria. Deneckere and Davidson (1985) show that mergers are profitable amongst price competing producers of differentiated brands, and much of the literature on mergers uses this framework (e.g., Werden (1996); Nevo (2000a); Jaffe and Weyl (2013); Miller, Remer, Ryan and Sheu (2013)).

³SABMiller and Molson Coors operate independently outside the United States and Puerto Rico. SABMiller owns 58% of the MillerCoors joint venture, and Molson Coors owns the remaining 42%.

interactions. The results indicate that emergent tacit collusion between MillerCoors and ABI best explains the data. We support this conclusion of the model with qualitative evidence from publicly available court documents and the financial reports of SABMiller and ABI. Lastly, we use counter-factual simulations to examine the welfare implications of the merger, both overall and by isolating specific mechanisms through which the merger affects outcomes. Among other results are (i) merger-specific cost reductions roughly counter-balance unilateral effects; (ii) consumer surplus loss is due to post-merger coordination between MillerCoors and ABI; and (iii) the merger increases total surplus, despite higher retail prices, due to the magnitude of marginal cost reductions.

The program evaluation results are based on supermarket scanner data that span 39 geographic regions over the period 2001-2011. Consequently, substantial data are available both before and after the Miller/Coors merger. We show that inflation-adjusted retail prices are stable about a small downward trend for at least seven years preceding the merger. This trend breaks dramatically and abruptly just after the merger. We estimate that the retail prices of ABI and MillerCoors brands increase by six percent, both in absolute terms and relative to the price changes of more distant substitutes. The retail price increases persist through the end of the data, and are apparent visually in graphs of inflation-adjusted prices over the sample period. We show that the sales volumes of ABI and MillerCoors decrease after the merger, again in absolute terms and relative to more distant substitutes. Considered together, these price and output effects are consistent with a negative supply-shock contemporaneous with the Miller/Coors merger.

The core of our paper investigates the causes of this negative supply shock and analyzes the mechanisms through which the Miller/Coors merger affects market outcomes. To make inferences about tacit collusion, we estimate models of demand and supply-side price competition in which a parameter governing post-merger coordination is nested inside the first-order conditions of MillerCoors and ABI. This modeling approach follows the proposal of Nevo (1998) for differentiated product markets. Recent research proves that the collusion parameter is identified if the available instruments generate sufficient exogenous variation in markups (Berry and Haile (2014)). Plausible instruments can be constructed from demand-shifters or changes in competitive environment (e.g., from variation in the number of firms). In our application, we invoke the program evaluation results and corroborating qualitative evidence to restrict parameter space such only a change in tacit collusion between MillerCoors and ABI is estimated. This solves a curse of dimensionality described in Nevo (1998), and motivates an identification strategy that exploits the merger itself as a shifter of the competitive environment, in the spirit of Berry and Haile (2014).

The key identifying assumption that enables supply-side estimation is that the unobservable marginal costs of ABI do not change, relative to those of more distant competitors, with the Miller/Coors merger. This allows us to identify the nature of post-merger competition based on relative changes in ABI prices – emergent tacit collusion is inferred if ABI prices in the post-merger periods exceed what would be predicted with Nash Bertrand competition.⁴ We implement by constructing instruments that equal one for ABI products in the post-merger periods. Given that the marginal cost specification incorporates product, region, and time fixed effects, this isolates the stated source of empirical variation. We supplement identification with market environment instruments based on median income and its interaction with product characteristics. Together, these instruments shift the endogenous markup terms in ways that plausibly are orthogonal to unobserved marginal costs. We summarize qualitative evidence in support of the restrictions in the body of the paper.⁵

We use three sets of instruments to estimate demand. First, we exploit variation in shipping distances, a key determinant of variable costs due to the bulk and weight of beer. Shipping distances vary across products, retail locations, and, because of how the Miller/Coors merger changed distribution, over time. This provides identifying power even as consumer indirect utility incorporates product, region and time fixed effects. Second, the merger itself represents a supply-shifter for ABI products, and this provides valid instruments for prices. The underlying restriction is that unobserved preferences for ABI beer do not change, relative to those of more distant competitors, with the Miller/Coors merger. These instruments arise naturally from the supply-side of the model but, to our knowledge, have not been used in the existing literature on demand estimation. Third, the panel structure of the data allows us to use interactions of median demographics and product characteristics as instruments. Shifts in such interactions affect firms’ pricing decisions and are helpful in identifying the non-linear parameters in the RCLM (e.g., Romeo (2014)).

The supply-side of the model reflects that beer, like many consumer products, is sold by retailers that intermediate between manufacturers and final consumers. Previous articles on the beer industry either assign monopoly power to the retail sector (e.g., Asker (2005); Hellerstein (2008); Goldberg and Hellerstein (2013)) or implicitly assume perfect competition

⁴Bias could arise if the model understates the degree to which prices are strategic complements, in which case unilaterally optimal price increases could be misdiagnosed as tacit collusion. However, we are skeptical that such misspecification bias, even if present, could fully explain our result.

⁵The instruments based on median income shift markups through their effect on demand, and are valid provided that unobserved marginal costs are orthogonal to consumer income. The instruments based ABI products in the post-merger period can be conceptualized as shifting markups through an effect on competitive intensity, and are valid given the stated assumption.

among retailers (e.g., Hausman, Leonard and Zona (1994); Slade (2004); Pinske and Slade (2004); Rojas (2008); Romeo (2014)). We build on this approach by incorporating a monopolistically competitive retail sector. The magnitudes of retail markups, retail pass-through, and double marginalization are determined by a scaling parameter that can be estimated or normalized.⁶ We show that supply-side estimation remains computationally tractable, even with the scaling parameter, leveraging an insight of Jaffe and Weyl (2013). While not our primary focus, the results indicate that retail markups are small, consistent with significant retail competition in the beer category or with vertical arrangements that mitigate double marginalization. Our results regarding post-merger tacit collusion are robust across different treatments of the retail sector.

We believe our paper to be the first to show empirically that mergers can soften competition through coordinated effects. Our findings support the relationship between market concentration and collusion that is posited in the theoretical literature and presumed in many antitrust investigations. Our research also contributes to a large and growing literature that applies program evaluation techniques to horizontal mergers (e.g., Peters (2006); Chandra and Collard-Wexler (2009); Weinberg and Hosken (2013); Allen, Clark and Houde (2014); Ashenfelter, Hosken and Weinberg (2013)).⁷ Among this literature, we are the first to decompose price effects into specific mechanisms through which mergers impact market outcomes. Our results underscore that coordinated effects and marginal cost efficiencies can have meaningful implications for market outcomes.

The articles closest to our research are Ciliberto and Williams (2014) and Ashenfelter, Hosken and Weinberg (2014b). The former estimates a model of airline competition in which the intensity of competition between any two carriers is allowed to vary with the degree of multimarket contact. Competitive intensity is captured by a parameter that appears inside firms' first-order pricing conditions, in a manner that is analogous to our approach. To our knowledge, the Ciliberto and Williams article represents the only other application of this methodology. Ashenfelter, Hosken and Weinberg (2014b) provide reduced-form evidence on the Miller/Coors merger. The article explains variation in price changes across geographic regions using how the merger would increase local market concentration and reduce shipping

⁶This retail scaling parameter is somewhat analogous to the double marginalization parameter introduced in Crawford, Lee, Whinston and Yurukoglu (2014). In that paper, the parameter governs the extent to which double marginalization arises among different divisions of the same firm. Here, it governs double marginalization through the supply-chain of the beer industry.

⁷Ashenfelter, Hosken and Weinberg (2014a) provide a comprehensive survey of this literature. Articles that use distant substitute brands as a comparison group in differences-in-differences regressions include Ashenfelter and Hosken (2010), McCabe (2002), and Ashenfelter, Hosken and Weinberg (2013).

distances. They find a negative relationship between prices and shipping distances and a positive relationship between prices and concentration. In contrast, we identify the supply-side parameters in our model by exploiting variation in price changes across brands, and use models of demand and supply-side price competition to isolate specific mechanisms through which the merger affect market outcomes and welfare.⁸

The paper is organized into eight sections. Section 2 provides background information on the U.S. beer industry and describes the datasets used in the analysis. Section 3 examines the time path of retail prices over the sample period and summarizes a body of qualitative evidence regarding tacit collusion between MillerCoors and ABI. Section 4 outlines the model, while Section 5 discusses estimation and identification. Section 6 presents the estimation results and evaluates the welfare implications of the merger. Section 7 evaluates a number of alternative explanations that (theoretically) could account for the observed retail price patterns. Section 8 concludes.

2 Industry Background and Facts to be Explained

2.1 Market structure

As do most firms in branded consumer product industries, brewers compete in prices, new product introductions, advertising and periodic sales. The beer industry differs from typical retail consumer product industries in its vertical structure because of state laws regulating the sales and distribution of alcohol. With few exceptions, brewers are prohibited by law from selling their products directly to retailers, restaurants, bars and final consumers.⁹ Instead, they typically sell their products to state-licensed distributors, who in turn sell to retailers. Payments along the supply-chain are regulated by federal law, and cannot include slotting fees, slotting allowances, or other fixed payments between firms.¹⁰ While retail price maintenance is technically illegal in many states, in practice distributors are often ex-

⁸By estimating the effects of the merger by comparing price changes across geographic regions, the estimates in Ashenfelter, Hosken and Weinberg (2014b) control for firm-specific cost shocks, but do not reflect any changes in prices caused by the merger that were in common to all local markets. Our approach instead places restrictions on firm-specific cost shocks, which enables us to incorporate price effects of the merger common across all local markets.

⁹In many states, establishments that serve food now are permitted to brew and sell beer. Tremblay and Tremblay (2005) discuss how regulatory changes have encouraged the entry of small brewers.

¹⁰The relevant statutes are the Alcoholic Beverage Control Act and the Federal Alcohol Administration Act, both of which are administered by the Bureau of Alcohol, Tobacco and Firearms (ATF). See the 2002 advisory posted by the ATF: <https://www.abc.ca.gov/trade/Advisory-SlottingFees.htm>, last accessed by the authors on November 4, 2014.

Table 1: Revenue Shares and HHI

Year	AB/ABI	MillerCoors	Miller	Coors	Modelo	Heineken	Total	HHI
2001	0.37	.	0.20	0.12	0.08	0.04	0.81	2,043
2003	0.39	.	0.19	0.11	0.08	0.05	0.82	2,092
2005	0.36	.	0.19	0.11	0.09	0.05	0.79	1,907
2007	0.35	.	0.18	0.11	0.10	0.06	0.80	1,853
2009	0.37	0.29	.	.	0.09	0.05	0.80	2,350
2011	0.35	0.28	.	.	0.09	0.07	0.79	2,162

Notes: The table provides revenue shares and the Herfindahl-Hirschman Index (HHI) over 2001-2011. Firm-specific revenue shares are provided for ABI, Miller, Coors, Modelo, Heineken. The total across these firms also is provided. The HHI is scaled from 0 to 10,000. The revenue shares incorporate changes in brand ownership during the sample period, including the merger of Anheuser-Busch (AB) and Inbev to form A-B Inbev (ABI), which closed in April 2009, and the acquisition by Heineken of the FEMSA brands in April 2010. All statistics are based on supermarket sales recorded in IRI scanner data.

pected to supply at wholesale prices set by brewers (Asker (2005)).¹¹ This mitigates pricing inefficiencies that otherwise would arise from double marginalization.

The production of beer remains dominated by a handful of large brewers, even with the recent growth of micro-breweries.¹² Table 1 shows revenue-based market shares at two-year intervals over 2001-2011, based on retail scanner data that we describe later in this section. Over the first half of the sample, the brands of five brewers – ABI, SABMiller, Molson Coors, Grupo Modelo, and Heineken – account for just over 80 percent of total retail revenue. ABI brands alone account for at least 35 percent of retail revenue in each year. The Miller/Coors joint venture, consummated in June 2008, consolidated the operations of the second and third largest firms into a single merged entity. In the latter years of the sample, the brands of MillerCoors account for 29 percent of retail revenue.¹³

The MillerCoors joint venture was announced on October 9, 2007, approved by the DOJ on June 5, 2008, and consummated on June 30, 2008. The stated rationale of the DOJ was that merger-specific cost reductions, related to transportation cost savings, likely

¹¹The U.S. Supreme Court’s decision in *Leegin Creative Leather Procuts Inc. v PSKS, Inc.*, 551 U.S. 877 (2007) changed RPM agreements from being per se illegal to judged under a rule-of-reason standard at the federal level, but RPM remains per se illegal in many states because federal law is superseded by state law.

¹²Brewing came to be dominated by national, mass-marketed brands in the 1950s and 1960s. A substantial body of literature examines the minimum efficient scale of production (e.g., see Tremblay and Tremblay (2005) for a review). One source of economies-to-scale is television advertising (e.g., George (2009)). Ascher (2012) also cites improvements in the highway system and the introduction of refrigerated trucks.

¹³The 2009 acquisition of Anheuser-Busch by Inbev formed the merged entity Anheuser-Busch Inbev (ABI). The merger did not raise substantial competitive concerns because Inbev’s U.S. sales were primarily from its Labatt’s brand, which was divested to obtain DOJ approval. We discuss how this acquisition affects our identification strategy in Section 5.3.

would dominate anticompetitive effects.¹⁴ While Coors beer was sold nationally, it was brewed only in Golden, Colorado and a secondary facility in Elkton, Virginia. SABMiller, by contrast, operated six plants dispersed across the U.S., enabling the merged entity to relocate the production closer to retail destinations. We have confirmed that Coors and Miller brands are now brewed in all eight plants. Both empirical research (e.g., Ashenfelter, Hosken and Weinberg (2014b)) and the company’s subsequent annual reports indicate that the anticipated cost reductions have been realized.

Consolidation in the industry has continued. In 2013, ABI acquired Grupo Modelo and its popular Corona brands. The DOJ challenged the acquisition and obtained a settlement in which the rights to market and distribute Grupo Modelo brands in the U.S. were divested to Constellation, a leading distributor of imported brands. Even more recently, Heineken rejected a takeover proposal from SABMiller in September 2014, and there is speculation in the popular press that ABI is preparing to acquire SABMiller.¹⁵

2.2 Data Sources

Our primary data source is retail scanner data from the IRI Academic Database (Bronnenberg, Kruger and Mela (2008)). The data include revenue and unit sales by UPC code, by week and store, for a sample of supermarkets that spans 47 distinct geographic regions over 2001-2011.¹⁶ In our empirical analysis, we focus on eleven flagship brands of ABI, Miller, Coors, Grupo Modelo, and Heineken.¹⁷ These brands account for 51 percent of all unit sales in the data, and are the locus of competition for the major brewers. We further focus on the sales of 12-packs (144 ounces) and 24-packs (288 ounces). In the beer sector, 12-packs produce the greatest number of unit sales and 24-packs account for the greatest sales volume. Together, they account for 63 percent of flagship brand unit sales in the sample.¹⁸ Throughout, we refer to brand-size combinations as distinct “products”.

¹⁴See the DOJ press release issued on June 5, 2008 (http://www.justice.gov/atr/public/press_releases/2008/233845.pdf), last accessed by the authors on November 3, 2014.

¹⁵See *The Economist*, “Foamy Wars: SABMiller May Be Swallowed up by Its Main Rival, AB Inbev.” September 20, 2014.

¹⁶Supermarkets account for 20 percent of off-premise beer sales. IRI also sells scanner data on drug stores and mass retailers, which account for three and six percent of off-premise beer sales, respectively. The other major sources of off-premise beer sales are liquor stores (38 percent) and convenience stores (26 percent). (McClain 2012)

¹⁷We define the flagship brands to be Bud Light, Budweiser, Miller Lite, Miller Genuine Draft, Miller High Life, Coors Light, Coors, Corona Extra, Corona Extra Light, Heineken, and Heineken Light.

¹⁸In some regions, 30-packs (360 ounces) are sold in lieu of 24-packs due to historical purchase patterns. We aggregate across these two package sizes to create a single, larger, package size. The bulk of omitted sales are made as 6-packs. The pricing and market share trends at that package size resemble those of 12-packs.

We aggregate volume, measured in 144 ounce equivalent units, and sales to the product-region-month level to reduce the computational burdens that arise in estimation and in the computation of equilibrium. We follow standard practice and measure retail prices as the ratio of revenue sales to equivalent unit sales, and market shares in 144 ounce equivalent units. These aggregations come with little loss of generality. Our identification strategy does not require week-to-week variation, as we detail below, and aggregation to the monthly level may even be helpful insofar as it reduces random measurement error. While the model incorporates heterogeneous marginal costs at the region-level, reflecting transportation costs, we are skeptical that store-specific effects are important and we do not incorporate them into the model.¹⁹ We restrict attention to 39 of the 47 geographic regions, dropping a handful of regions in which either few supermarkets are licensed to sell beer or supermarkets are restricted to selling low alcohol beer.²⁰ With these aggregations and exclusions, the IRI Academic Database provides 94,837 observations at the product-region-period level.

In order to better model consumer demand, we supplement the IRI scanner data with data on household demographics from the Public Use Microdata Sample (PUMS) of the American Community Survey. In particular, we use the PUMS income data, along with period fixed effects, to help control for changing macroeconomic conditions during the sample period. The PUMS data are available annually over 2005-2011. Monthly variation in demographics is unavailable. Households are identified as residing within specified geographic areas, each of which has at least 100,000 residents based on the 2000 Census. We merge the PUMS data to the IRI scanner data by matching on the counties that compose the IRI regions and the PUMS areas. In estimation of our demand and oligopoly models, we restrict attention to the 2005-2011 period, based on the intersection of the sample periods. There are 53,543 observations at the product-region-period level in this sample.

Lastly, we obtain the driving miles between each IRI region and the nearest brewery for each product in our sample using Google Maps, in order to model transportation costs. For imported brands, we define the miles traveled based on the nearest port into which the beer is shipped.²¹ We construct a notion of “distance” based on the interaction of driving

¹⁹While aggregating over stores could generate spurious substitution if not all brands are carried by all supermarkets, we do not believe this is a meaningful concern given our focus on flagship brands.

²⁰The regions included in our sample are: Atlanta, Birmingham/Montgomery, Boston, Buffalo/Rochester, Charlotte, Chicago, Cleveland, Dallas, Des Moines, Detroit, Grand Rapids, Green Bay, Hartford, Houston, Indianapolis, Knoxville, Los Angeles, Milwaukee, Mississippi, New Orleans, New York, Omaha, Peoria/Springfield, Phoenix, Portland OR, Raleigh/Durham, Richmond/Norfolk, Roanoke, Sacramento, San Diego, San Francisco, Seattle/Tacoma, South Carolina, Spokane, St. Louis, Syracuse, Toledo, Washington D.C., and West Texas/New Mexico.

²¹We obtain the location of Heineken’s primary ports from the website of BDP, a logistics firm hired

miles and diesel fuel prices, which we obtain from the Energy Information Agency of the Department of Energy. This allows us to capture variation in transportation costs that arises both cross-sectionally, based on the location of regions and breweries, and inter-temporally, based on fluctuations in fuel costs. It also allows us to capture empirically the distributional cost-savings of the Miller/Coors merger. All prices and incomes are deflated using the CPI and are reported in 2010 dollars.

3 Trends in Retail Prices

3.1 Quantitative evidence

Figure 1 plots the average regional log retail price of 12-packs, over 2001-2011, for three of the four best selling brands of beer: Bud Light, Miller Lite, and Coors Light.²² Also shown are prices for Corona Extra and Heineken, the leading brands of Grupo Modelo and Heineken, respectively. The vertical axis is the natural log of the price, measured in 2010 dollars. The vertical bar drawn at June 2008 signifies the consummation of the Miller/Coors merger. Horizontal ticks are shown at October of each year, in order to highlight an industry practice in which some large brewers adjust prices each year in early autumn.²³

The retail prices of these five brands are stable around a downward trend for the seven and a half years prior to the Miller/Coors merger. The trend is abruptly interrupted in the first autumn after the merger, specifically for Bud Light, Miller Lite and Coors Light. Average prices increase at that time by about eight percent for each of those brands. Notably, the ABI price increases are nearly equal those of MillerCoors. These increases persist through the end of our sample and well exceed historical price fluctuations in magnitude. The retail prices of Corona Extra and Heineken do not move noticeably with the merger, and instead continue along the initial trend.²⁴

To better quantify these effects, we estimate “difference-in-differences” regression equa-

by Heineken to improve its operational efficiency. See <http://www.bdpinternational.com/clients/heineken/>, last accessed on February 26, 2015. The ports include Baltimore, Charleston, Houston, Port of Long Beach, Miami, Seattle, Oakland, Boston, and New York. We measure the shipping distance for Grupo Modelo brands as the driving distance from each retail location to Ciudad Obregon, Mexico.

²²We exclude Budweiser, the second-best selling brand, because its prices largely track those of Bud Light.

²³This practice is described in the Department of Justice’s complaint to enjoin Anheuser-Busch Inbev’s attempted purchase of Grupo Modelo. More detail is provided in Section 3.2.

²⁴We do not know why the retail prices of Miller Lite take a brief downturn over July- August of 2008, but this temporary price decrease also is apparent in other sources of retail pricing data (e.g., Ashenfelter, Hosken and Weinberg (2014b)). It does not affect estimation because we exclude the period June 2008-May 2007 from the regression sample.

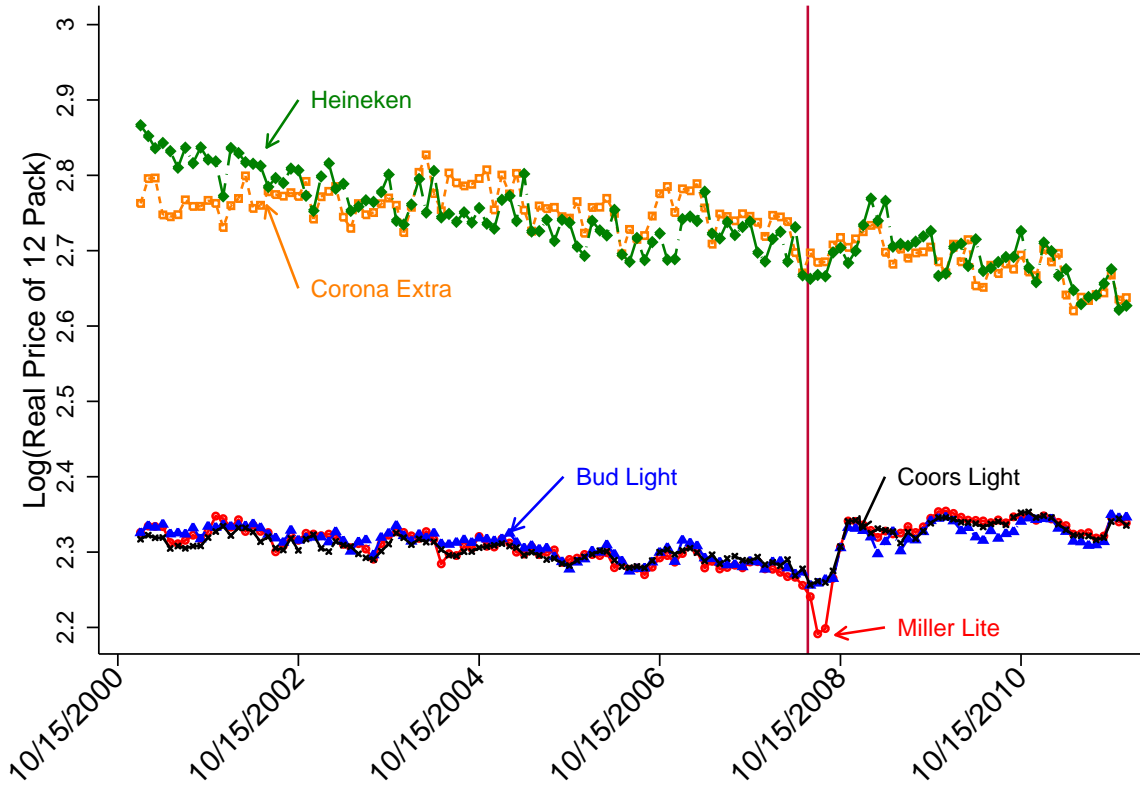


Figure 1: Average Retail Prices of Flagship Brand 12-Packs

Notes: The figure plots the national average price of a 12-pack over 2001-2011, separately for Bud Light, Miller Lite, Coors Light, Corona Extra and Heineken. The vertical axis is the natural log of the price in real 2010 dollars. The vertical bar drawn at June 30, 2008 signifies the consummation of the Miller/Coors merger. Horizontal ticks are shown at October of each year due to an industry practice in which brewer prices are adjusted in early autumn.

tions that allow us to contrast the price changes for ABI and Miller/Coors brands with those for Grupo Modelo and Heineken brands. The baseline regression equation specifies the log retail price of product j in region r during period t according to

$$\begin{aligned} \log p_{jrt}^R &= \beta_1 \mathbb{1}\{\text{ABI or MillerCoors}\}_{jt} \times \mathbb{1}\{\text{Post-Merger}\}_t \\ &+ \beta_2 \mathbb{1}\{\text{Post-Merger}\}_t + \phi_{jr} + \tau_t + \epsilon_{jrt} \end{aligned} \quad (1)$$

which features indicator variables for (i) the ABI and MillerCoors brands in the post-merger periods, and (ii) all products in the post-merger periods. We incorporate product fixed effects interacted with region fixed effects, through the parameters ϕ_{jr} , and either a linear time trend or period fixed effects through the parameters τ_t .²⁵ The period fixed effects, in

²⁵In specifications that include period fixed effects, we omit the indicator $\mathbb{1}\{\text{Post-Merger}\}_t$ as it is collinear

particular, account for changes in macroeconomic conditions.

Table 2 presents the results.²⁶ Columns (i)-(iii) incorporate a linear time trend and the post-merger dummy, while columns (iv)-(vi) control for period fixed effects. The sample used in column (i) includes 12-packs of Bud Light, Coors Light, Miller Lite, Heineken and Corona Extra (which corresponds exactly to Figure 1). The regression coefficients indicate that ABI and MillerCoors prices increased by nine percent, relative to Heineken and Corona, after the merger. The absolute increase is roughly six percent. Column (ii) expands the sample to both 12-packs and 24-packs. Both the relative and absolute price increases are estimated around five to six percent. Column (iii) further adds to the sample Budweiser, Miller Genuine Draft, Miller High Life, Corona Extra Light, and Heineken Light. The results are unchanged. With more flexible controls for inter-temporal effects, as shown in columns (iv)-(vi), the relative price increases are essentially identical but absolute price increases are not identified.²⁷

3.2 Qualitative evidence of tacit collusion

There is substantial qualitative evidence that the ABI and MillerCoors price increases are due to tacit collusion in the wake of the Miller/Coors merger. We draw first on the Complaint filed by the DOJ to enjoin the acquisition of Grupo Modelo by ABI. The Complaint alleges that ABI and MillerCoors announce (nominal) price increases each year in late summer to take effect in early fall. In most geographic areas, ABI is the market share leader and announces its price increase first; in some other markets MillerCoors announces first. These announcements are transparent and generally have been matched. The Complaint quotes from the normal course documents of ABI:

The specifics of ABI’s pricing strategy are governed by its “Conduct Plan,” a strategic plan for pricing in the United States that reads like a how-to manual for successful price coordination. The goals of the Conduct Plan include “yielding the highest level of followership in the short-term” and “improving competitor conduct over the long-term.”

with the time effects.

²⁶These results are robust to measuring price in levels instead of logs.

²⁷There is no statistical evidence that the pre-merger time trends differ between ABI/MillerCoors and Modelo/Heineken. To investigate, we regress log prices on interactions between the *BudMillerCoors* dummy and dummies for each time period in our data, region/product effects, and dummies for each time period in our data. We project the coefficients on the interaction terms from time periods prior to the merger onto a linear trend and used the delta-method to test the null hypothesis that the coefficient on the trend was zero. The point estimate of the difference in the pre-merger price trends between Miller/Coors/Bud brands and Heineken/Corona brands is approximately zero and the p -value for the test is 0.611.

Table 2: OLS Regression Results for Retail Prices

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
$\mathbb{1}\{\text{ABI or MillerCoors}\}$	0.094***	0.057***	0.060***	0.094***	0.057***	0.062***
$\times \mathbb{1}\{\text{Post-Merger}\}$	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)
$\mathbb{1}\{\text{Post-Merger}\}$	-0.031***	-0.006	-0.011	-	-	-
	(0.005)	(0.008)	(0.007)	-	-	-
Period Fixed Effects	No	No	No	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	No	No	No
# Obs.	25,740	44,621	94,837	25,740	44,621	94,837

Notes: All regressions include product fixed effects interacted with region fixed effects. The dependent variable is log real retail price. Observations are at the product-region-period level. Columns (i) and (iv) contain 12-packs of Bud Light, Coors Light, Miller Lite, Corona Extra, and Heineken. Columns (ii) and (v) contains 12-packs and 24-packs of the same brands. Columns (iii) and (vi) contain 12-pack and 24-packs of these brands plus Budweiser, Coors, Miller Genuine Draft, Miller High Life, Corona Light, and Heineken Premium Light. The estimation sample spans 39 regions from 2001-2011. Standard errors are clustered at the region level and reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

ABI’s Conduct Plan emphasizes the importance of being “Transparent – so competitors can clearly see the plan;” “Simple – so competitors can understand the plan;” “Consistent – so competitors can predict the plan;” and “Targeted – consider competition’s structure.” By pursuing these goals, ABI seeks to “dictate consistent and transparent competitive response.”

As one ABI executive wrote, a “Front Line Driven Plan sends Clear Signal to Competition and Sets up well for potential conduct plan response.” According to ABI, its Conduct Plan “increases the probability of [ABI] sustaining a price increase.”

A similar narrative can be constructed with the annual reports of the companies. SABMiller implemented a “turnaround plan” in 2002 that increased marketing spend especially for the Miller Lite and Miller Genuine Draft brands. In 2005, it described “intensified competition” and an “extremely competitive environment.” The same year, Anheuser-Busch reported that it was “collapsing the price umbrella by reducing our price premium relative to major domestic competitors.” SABMiller characterized price competition as “intense” in 2006 and 2007. The tenor of the annual reports changes markedly after the Miller/Coors merger. In 2009, SABMiller attributed increasing earnings before interest, taxes, and amortization expenses to “robust pricing” and “reduced promotions and discounts.” In 2010 and 2011, respectively, it referenced “sustained price increases” and “disciplined revenue

management with selected price increases.”²⁸

Furthermore, the available qualitative evidence supports that tacit collusion is limited to ABI and MillerCoors. The aforementioned DOJ Complaint alleges that Grupo Modelo did not join the price increases and instead adopted a “Momentum Plan” that was designed to “grow Modelo’s market share by shrinking the price gaps between brands owned by Modelo and domestic premium brands.” The practical consequence is that the nominal prices of Grupo Modelo have remained flat even as ABI and MillerCoors prices have increased. The Complaint is silent regarding the pricing practices of Heineken, though in the retail sales data we examine, the price on Heineken brand beer is similar to that of Corona.

4 Model

4.1 Overview

We estimate a model of price competition among producers of differentiated products. The supply-side features an oligopoly of brewers that sells to consumers through a monopolistically competitive retail sector. Prices are linear, consistent with industry regulations against slotting allowances, and double-marginalization arises in equilibrium. Competition among brewers follows Nash-Bertrand principles. In periods after the Miller/Coors merger, we incorporate a parameter that allows ABI and MillerCoors to internalize the effects of their competition on each other. We also incorporate a scaling parameter that determines the magnitudes of retail market power and pass-through. Distributors are not included in the model explicitly and can be conceptualized as subsumed within the retail sector.²⁹

We use the random coefficients logit model (RCLM) of Berry, Levinsohn and Pakes (1995) to model the demand-side. We rely on a specification in which income affects (i) preferences for imported brands of Corona and Heineken, relative to the flagship brands of ABI and MillerCoors; and (ii) preferences for imports and the flagship brands of ABI and MillerCoors, relative to the outside good. This specification is parsimonious yet flexible along the dimensions most important to our application. The RCLM frequently has been applied to the beer industry because it allows for the estimation of reasonable consumer

²⁸See the SABMiller Annual Report in 2005 (p. 13), 2006 (p. 5), 2007 (pp. 4 and 8), 2009 (p. 9 and 24), 2010 (pp. 29) and 2011 (p. 28), and the Anheuser-Busch Annual Report in 2005 (p. 5). The ABI annual reports in the post-merger years are more opaque.

²⁹Hellerstein (2008) and Goldberg and Hellerstein (2013) employ a similar framework that features Nash-Bertrand competition among brewers and a retail monopolist. Asker (2005) models distributors explicitly but assumes that they are passive players.

substitution patterns with aggregated data (e.g., Asker (2005), Hellerstein (2008), Romeo (2014), Goldberg and Hellerstein (2013)).³⁰

4.2 Supply

Let there be $m = 1 \dots M$ distinct markets. These are region-period combinations in our application. Markets include a set of homogeneous retailers, each of which sets prices to maximize its profit taking as given its marginal cost and brewers' prices. Competition in the retail sector is monopolistically competitive because retailers do not consider the prices of their competitors when maximizing profit. This greatly simplifies the modeling relative to the alternative of modeling oligopoly interactions among retailers. The first-order conditions that determine retail pricing in each market m are given by

$$f(p_{.m}^R) \equiv p_{.m}^R - p_{.m}^B - mc_{.m}^R + \lambda \left[\left(\frac{\partial s_{.m}(p_{.m}^R; \theta^D)}{\partial p_{.m}^R} \right)^T \right]^{-1} s_{.m}(p_{.m}^R; \theta^D) = 0, \quad (2)$$

where $p_{.m}^R$ and $p_{.m}^B$ are vectors of retail and brewer prices, respectively, $mc_{.m}^R$ is a vector of retail marginal costs, $s_{.m}(p_{.m}^R; \theta^D)$ is a vector of market shares, and λ is a scaling parameter that determines retail market power and pass-through. This nests perfect retail competition ($\lambda = 0$), in which there is no double marginalization and retailers fully pass-through changes in brewer prices, as well as retail monopoly ($\lambda = 1$).³¹

Brewers set their prices with knowledge of equation (2). Assuming the existence of pure-strategy equilibrium in prices, the first-order conditions are

$$p_{.m}^B = mc_{.m}^B - \left[\Omega_m \circ \left(\frac{\partial p_{.m}^R(p_{.m}^B; mc_{.m}^R, \theta^D)}{\partial p_{.m}^B} \right)^T \left(\frac{\partial s_{.m}(p_{.m}^R; \theta^D)}{\partial p_{.m}^R} \right)^T \right]^{-1} s_{.m}(p_{.m}^R; \theta^D), \quad (3)$$

where $mc_{.m}^B$ is the vector of brewer marginal costs, Ω_m is the ownership matrix, and the operation \circ is element-by-element matrix multiplication. The (j, k) element of the ownership

³⁰Other frameworks are viable. Slade (2004) and Pinske and Slade (2004) estimate both the nested logit model and linear demands, using techniques developed in Pinkse, Slade and Brett (2002), to study market power and mergers in the U.K. beer industry. Rojas (2008) estimates the almost ideal demand system of Deaton and Muellbauer (1980) using the techniques in Pinkse, Slade and Brett (2002). Hausman, Leonard and Zona (1994) use multi-stage budgeting with a linear approximation to the almost ideal demand system at the bottom level of demand.

³¹Perfect retail competition and retail monopoly are among the non-nested supply systems considered by Villas-Boas (2007) in a study of double marginalization in the U.S. yogurt industry. Intermediate ranges of the retail scaling parameter correspond loosely to intermediate levels of retail market power. To our knowledge, there is no direct mapping into an oligopoly model.

matrix equals one if products j and k are produced by the same firm. We allow for a range of values if j and k are produced by ABI and MillerCoors and the market postdates the Miller/Coors merger. Otherwise it equals zero. Mathematically, our baseline specification is

$$\Omega_m(j, k; \kappa) = \begin{cases} 1 & \text{if } j, k \text{ produced by same brewer} \\ \kappa & \text{if } j, k \text{ produced by ABI and MillerCoors} \\ & \text{after the Miller/Coors merger} \\ 0 & \text{otherwise.} \end{cases} \quad (4)$$

The scalar κ is the collusion parameter referenced earlier in the paper. The specification is motivated by the qualitative evidence in the DOJ Complaint filed to enjoin the acquisition of Grupo Modelo by ABI, as well as by the reduced-form evidence about retail prices.³² We discuss interpretation and identification in Section 5.3. Here we note only that the collusion parameter is best interpreted as summarizing a change that arises in the wake of the Miller/Coors merger, because competition is normalized to Nash-Bertrand in the pre-merger periods. Retail pass-through enters the first-order conditions directly, and can be calculated in a manner consistent with the underlying demand schedule and the retail scaling parameter. We defer details on retail pass-through to Section 5.2.

We specify a marginal cost function that incorporates product- and market-level heterogeneity, and captures the cost efficiencies of the Miller/Coors merger. Because the marginal costs of brewers and retailers are not separably identifiable within our framework, we parameterize a joint marginal cost function according to

$$mc_m(\gamma) = mc_m^R(\gamma) + mc_m^B(\gamma) = W_m \gamma + \sigma_j^S + \mu_c^S + \tau_t^S + \omega_m, \quad (5)$$

where W_m is a matrix of cost variables, σ_j^S , μ_c^S , and τ_t^S are product, region, and period fixed effects, respectively, and ω_m is a vector of unobservable marginal costs. We proxy shipping costs using a distance variable calculated as the miles between the region and brewery, interacted with the price of diesel fuel. This captures the cost savings of the Miller/Coors merger that arise from moving the production of Coors' products into Miller breweries that are closer to retailers and vice versa. We also include an indicator variable for MillerCoors products in the post-merger periods to account for residual merger synergies unrelated to distribution.

We treat the vector of unobserved marginal costs as a structural error term. Combining

³²The specific timing assumption in this specification is unimportant in estimation because we exclude the months between June 2008 and May 2009 from the sample (i.e., one year of post-merger data).

equations (2), (3), and (5), the structural error term is

$$\omega_{.m}^R = p_{.m}^R - W_m \gamma - \left(\underbrace{-\lambda \left[\left(\frac{\partial s_{.m}}{\partial p_{.m}^R} \right)^T \right]^{-1}}_{\text{retail markup}} s_{.m} - \underbrace{\left[\Omega_m(\kappa) * \left(\frac{\partial p_{.m}^R(\lambda)}{\partial p_{.m}^B} \right)^T \left(\frac{\partial s_{.m}}{\partial p_{.m}^R} \right)^T \right]^{-1}}_{\text{brewer markup}} s_{.m} \right), \quad (6)$$

where we have suppressed selected function arguments for brevity. The supply-side parameters to be estimated are $\theta^S = (\gamma, \kappa, \lambda)$. The marginal cost parameters enter equation (6) linearly, the brewer collusion parameter enters nonlinearly through the ownership matrix, and the retail scaling parameter enters both linearly through the retail markup and nonlinearly through the retail pass-through matrix.

4.3 Demand

We model demand using the RCLM. Consider demand in some market m , again defined in our application as a region-period combination. The conditional indirect utility that consumer i receives from product j in market m is

$$u_{ijm} = x_j \beta_i^* - \alpha p_{jm}^R + \sigma_j^D + \mu_c^D + \tau_t^D + \xi_{jm} + \epsilon_{ijm}, \quad (7)$$

where x_j is a vector of observable product characteristics, p_{jm}^R is the retail price, σ_j^S , μ_c^S , and τ_t^S are product, region, and period fixed effects, respectively, and ξ_{jm} captures product- and market-specific deviations in the mean consumer valuation. The stochastic term ϵ_{ijm} is mean zero and has a Type I extreme-value distribution.

We express the individual-specific taste parameters as a function of structural parameters and consumer income:

$$\beta_i^* = \beta + \Pi D_i, \quad (8)$$

where D_i is income.³³ The product characteristics include a constant and an indicator that equals one for Corona and Heineken brands. This specification is parsimonious yet flexible along the dimensions most important to our application. First, it breaks the independence of

³³In many applications of the RCLM, the individual-specific taste parameters also are allowed to vary with unobserved demographics, simulated numerically. When incorporated here, the corresponding coefficients are small and statistically insignificant, so we opt for the simpler specification. We also find that incorporating other observable demographics, such as age and race, has little impact on the obtained elasticities.

irrelevant alternatives (IIA) property of logit demand between the imported brands and the flagship domestic brands of ABI and MillerCoors. Second, it allows the consumer demand for beer to shift in a natural way with the onset of the recession, which roughly coincides with the MillerCoors merger. The demand-side parameters to be estimated include (α, β, Π) .

We complete the demand system by allowing consumers to forgo purchase of the major beer brands through the grocery channel. The conditional indirect utility that consumer i receives from the outside good in market m is

$$u_{i0m} = \xi_0 + \epsilon_{i0m}, \quad (9)$$

where ξ_0 is the mean consumer valuation. The mean utility ξ_0 is not identified, and we follow convention and normalize it to zero. We define the total potential market size to be ten percent greater than the maximum observed unit sales in each market. This approach is pragmatic and produces elasticities that are in line with the literature and generate plausible markups.³⁴

We define the vector of demand parameters $\theta^D = (\theta_1^D, \theta_2^D)$ such that $\theta_1^D = (\alpha, \beta)$ includes the parameters that enter the objective function linearly while $\theta_2^D = (\Pi)$ includes the nonlinear parameters. Equations (7) and (8) can be combined such that

$$\begin{aligned} u_{ijm} &= \delta(x_j, p_{jm}^R, \sigma_j^D, \mu_c^D, \tau_t^D, \xi_{jm}; \theta_1^D) + \mu_{ijm}(x_j, D_i; \theta_2^D) + \epsilon_{ijm}, \\ \delta_{jm} &= x_j\beta - \alpha p_{jm}^R + \sigma_j^D + \mu_c^D + \tau_t^D + \xi_{jm}, \quad \mu_{ijt} = x_j\Pi D_i, \end{aligned} \quad (10)$$

where δ_{jm} is the mean consumer valuation of product j in market m and depends only on the linear parameters, while $\mu_{ijm} + \epsilon_{ijm}$ is the consumer-specific deviation and depends on the nonlinear parameters. The choice probabilities that arise with the RCLM are widely published, and for brevity we refer readers to Nevo (2001).

³⁴Market size is held constant over time in each region. We experimented with the population-based market size definitions that are featured in the existing literature on beer markets (e.g., Asker (2005), Hellerstein (2008); Romeo (2014); Goldberg and Hellerstein (2013)). In our data, this generates an unreasonable amount of cross-region heterogeneity in the outside good shares, plausibly due to regional differences in the proportion of supermarkets that report to IRI. This swamps other sources of variation and makes it difficult to identify the nonlinear demand parameters. Our approach sidesteps the problems posed by the mismatch between population and IRI-reported sales volumes. We provide additional details on our treatment of market size and outside good shares in Appendix A.

5 Estimation

5.1 Moments and the objective function

We estimate the demand and supply parameters separately for computational reasons detailed in the next subsection. On the demand-side, we employ the nested fixed point approach of Berry, Levinsohn and Pakes (1995). For each vector of candidate nonlinear demand parameters, a contraction mapping computes the vector of mean utility levels δ^* that solves the implicit system of equations $s(x, p^R, \delta^*; \theta_2^D) = S$, where S is the vector of observed market shares. We then obtain

$$\xi_{jm}^*(\theta^D) = \delta_{jm}^*(x, p_{.m}^R, \delta_{.m}^*; \theta_2^D) - (x_j \beta - \alpha p_{jm}^R) \quad (11)$$

for each product j and market m . Let $\xi = [\xi'_{.1}, \xi'_{.2}, \dots, \xi'_{.M}]'$ stack the market-varying unobserved product characteristics, and let Z be a matrix of instruments. Then under the identifying assumption that $E[\xi|Z] = 0$, the GMM demand estimates are defined by

$$\hat{\theta}^D = \arg \min_{\theta^D} \xi^*(\theta^D)' Z A^{-1} Z' \xi^*(\theta^D), \quad (12)$$

where A is a positive definite weighting matrix. The demand parameters $\theta_1^D = (\alpha, \beta)$ enter the objective function linearly and we concentrate these parameters out of the optimization problem using 2SLS, following standard practice. We estimate demand with the standard two step procedure (e.g., Hansen (1982)), setting $A = Z'Z$ in the first step and then using estimates of the optimal weight matrix in the second step. The optimal weight matrix was estimated with a Eicker-White-Huber cluster robust covariance estimator that allows for heteroskedasticity, autocorrelation and within-region cross-product correlations (Bhattacharya 2005). We compute the contraction mapping separately for each market, using a tolerance of 1e-14. Details on the demand-side estimation, including checks to assess whether the estimator correctly identifies a global minimum of the objective function, are provided in Appendix A.

We estimate the supply-side of the model taking as given the demand estimates. For each vector of candidate supply-side parameters, we calculate the implied brewer markups, retail markups, and observed costs, and obtain the vector $\omega^*(\theta^S; \hat{\theta}^D)$ based on equation (6). Let $\omega = [\omega'_{.1}, \omega'_{.2}, \dots, \omega'_{.M}]'$ stack the unobserved costs that arise in each market, and let Z be a matrix of instruments. Then under the identifying assumption that $E[\omega|Z] = 0$, the

GMM supply estimates are defined by

$$\hat{\theta}^S = \arg \min_{\theta^S} \omega^*(\theta^S; \hat{\theta}^D)' Z C^{-1} Z' \omega^*(\theta^S; \hat{\theta}^D) \quad (13)$$

where C is a positive definite weighting matrix. The cost parameter γ enters the objective function linearly, and we concentrate it out of the optimization problem using 2SLS. We again employ the standard two step procedure and estimate a second step weighting matrix with region-level clustering. We adjust standard errors to account for the incorporation of demand-side estimates following Wooldridge (2010).³⁵

5.2 Retail pass-through

In this section, we derive retail pass-through formally, explain its impact on computational burden, and introduce a methodology that enables supply-side estimation. We start with the observation of Jaffe and Weyl (2013) that the implicit function theorem can be applied to derive the following expression for pass-through:

$$\frac{\partial p_{.m}^R}{\partial p_{.m}^B} = - \left(\frac{\partial f(p_{.m}^R)}{\partial p_{.m}^R} \right)^{-1} \quad (14)$$

where the vector $f(p_{.m}^R)$ is defined in equation (2). By inspection, the Jacobian matrix on the right-hand-side depends on both the first and second derivatives of demand. For any set of demand parameters, retail pass-through can be calculated by (i) numerically integrating over the consumer draws to obtain the $J \times J$ matrix of first derivatives and the $J \times J \times J$ array of second derivatives; (ii) manipulating these to obtain $\partial f(p_{.m}^R)/\partial p_{.m}^R$; and (iii) obtaining the opposite inverse of the Jacobian. Due to memory constraints, we find that it is fastest to compute pass-through on a market-by-market basis, so steps (i)-(iii) are repeated for every region-period combination in the data. With joint estimation of supply and demand, all of the above additionally must be repeated for each candidate parameter vector, and the GMM objective function becomes difficult to minimize in a reasonable time.

It is more expedient to estimate the supply-side separately, taking as given the results of the demand-side. With the obtained demand parameters, we first calculate $\partial f(p_{.m}^R)/\partial p_{.m}^R$ for each market, integrating numerically over consumer demographics using a frequency simulator, under the assumption that the retail scaling parameter (i.e., λ) equals one. It is then simple to adjust the Jacobian term in accordance with any candidate retail scaling param-

³⁵We provide the mathematical details of the adjustment in Appendix B.

eter under consideration. To clarify this procedure, we provide a closed-form expression for column n of the Jacobian term. Suppressing market-level subscripts, the column vector is given by

$$\frac{\partial f^R(p^R)}{\partial p_n} = - \begin{bmatrix} 0 \\ \vdots \\ 1 \\ 0 \\ \vdots \end{bmatrix} + \lambda \left[\frac{\partial s}{\partial p^R} \right]^T^{-1} \left[\frac{\partial^2 s}{\partial p^R \partial p_n} \right]^T \left[\frac{\partial s}{\partial p^R} \right]^T^{-1} s - \lambda \left[\frac{\partial s}{\partial p^R} \right]^T^{-1} \left[\frac{\partial s}{\partial p_n} \right]^T, \quad (15)$$

where the 1 in the initial vector is in the n^{th} position. In supply-side estimation, we start with the Jacobian obtained under the assumption $\lambda = 1$ and then, for each vector of candidate supply-side parameters, we (i) subtract the identity matrix from the initial Jacobian, (ii) scale the remainder by λ , (iii) add back the identity matrix; and (iv) take the opposite inverse to obtain a retail pass-through matrix that is fully consistent with the candidate parameter vector under consideration. This eliminates the need to obtain first and second demand derivatives, via numerical integration, at each candidate parameter vector. Thus, it is possible to estimate the demand and supply parameters (separately) with only a single application of numerical integration to obtain pass-through.

5.3 Identification and instruments

5.3.1 Supply-side identification

We make two identifying assumptions to obtain the supply-side parameters. The first is that region-specific changes in consumer income, which affect demand, are orthogonal to unobserved changes in marginal costs.³⁶ The second is that the unobserved costs of ABI brands do not change, relative to the those of Corona and Heineken, following the Miller/Coors merger. This latter assumption drives the identification of tacit collusion because it allows us to infer an increase in the brewer collusion parameter if the ABI price increases in the wake of the Miller/Coors merger exceed what can be rationalized with Nash-Bertrand competition.

We implement the identifying assumptions by constructing instruments based on (i) median region income; (ii) indicators that equal one for ABI brands after the Miller/Coors

³⁶This first identifying assumption would be violated, for example, if marginal costs decrease particularly in regions that experience greater adverse macroeconomic shocks. Given the presence of region and period fixed effects in the marginal cost specification, the assumption is not violated by persistent heterogeneity across regions or by macroeconomic shocks that affect marginal costs equally across regions.

merger, separately for 12-packs and 24-packs; (iii) the interactions of median income with these ABI indicators; and (iv) the interaction of median income with an indicator for imported brands. The power of the post-merger ABI indicators in predicting markups is supported by the reduced-form regression results. Identification rests on product-specific changes over time, because the marginal cost specification incorporates region, period, and product fixed effects. Further, the marginal cost specification includes an indicator for Miller-Coors brands post-merger, so placing the ABI indicators into the instrument set enforces that any changes in the unobserved costs of ABI are orthogonal to those of Corona and Heineken. Restrictions are not imposed on how marginal costs of the MillerCoors products change with the merger.

That these assumptions are sufficient for supply-side identification can be illustrated by returning to the first-order conditions summarized in equation (6). If the retail scaling parameter and the brewer collusion parameter are to be identified separately, what is required is exogenous variation that shifts the retail and brewer markups differentially. Our instruments provide this variation. Consumer income affects both retail and brewer markups, through the demand derivatives. The indicator for ABI brands after the Miller/Coors merger also affects both markups, but it has a substantially larger impact on brewer markups under reasonable retail pass-through conditions.³⁷ Thus, the two identifying assumptions together provide sources of empirical variation that affect retail and brewer markups differentially, enabling estimation of the supply-side parameters.

Our empirical strategy is best interpreted as summarizing a change in tacit collusion that arises after the MillerCoors merger. In principle, both the pre-merger and post-merger levels of collusion are identified in the presence of a demand-shifter with sufficient variation in the instrument set (Berry and Haile (2014)). While we do include median income as an instrument, its identifying power is insufficient for the estimation of collusion levels. Thus, an additional assumption is required to make progress, and we normalize pre-merger competition to Nash-Bertrand. Alternatives are possible. For example, in robustness checks we incorporate a nonzero pre-merger collusion parameter. Provided this parameter is not too large, the result that tacit collusion increases in the post-merger periods is robust.³⁸

³⁷Suppose that the ABI markup increases by \$1.00 after the Miller/Coors merger. If retail pass-through is roughly complete, as we estimate it to be, then the retail markup is unaffected because retail prices also increase by \$1.00. There is a differential impact on brewer markups unless retail pass-through is well more than complete. Specifically, the retail price must increase by exactly \$2.00, in response to the \$1.00 increase in the ABI price, if the differential effect is to be eliminated.

³⁸Our identification strategy is analogous to that of Ciliberto and Williams (2014), which imposes implicitly that airline carriers with infinitely negative multi-market contacts compete ala Nash Bertrand. Of course, negative multi-market contacts are impossible in practice. Given the results reported for the baseline

5.3.2 Demand-side identification

We make three main identifying assumptions to recover the demand-side parameters. The first is that unobserved preferences are orthogonal to the distance between the region and the brewery. This allows the marginal cost variables related to distance, which capture distribution costs, to serve as instruments. Second, we assume that unobserved preferences for ABI and MillerCoors brands do not change, relative to those for Corona and Heineken, following the Miller/Coors merger.³⁹ Third, we assume that unobserved preferences are orthogonal to median market income, keeping in mind that how income effects consumer-specific preferences is incorporated directly through the random coefficients. This final assumption follows the finding of Romeo (2014) that the use of mean demographics as instruments improves numerical performance in the estimation of the RCLM. It does not materially affect the price coefficient or the supply-side estimates.

We implement the identifying assumptions by constructing instruments based on (i) the distance between the region and the relevant brewery, separately for 12-packs and 24-packs, where distance is calculated as the interaction of miles and the price of diesel fuel; (ii) indicators that equal one for ABI and MillerCoors brands after the Miller/Coors merger, separately for 12-packs and 24-packs; (iii) median region income; (iv) median income interacted with the distance instruments; (v) median income interacted with the ABI/MillerCoors indicators; (vi) median income interacted with an indicator that equals one for imported brands. The power of the post-merger ABI indicators in predicting retail prices is demonstrated by the reduced-form regression results. Identification rests on product-specific changes over time, because the specification incorporates region, period, and product fixed effects.⁴⁰

specification, it can be calculated that competition between carriers with no multi-market contact is governed by a collusion parameter of 0.04, which is nearly Nash Bertrand (see Column 3 of Table 5 in Ciliberto and Williams (2014)).

³⁹A slightly weaker identifying assumption is that unobserved preferences for ABI brands do not change, relative to those for Corona and Heineken, following the Miller/Coors merger. This can be implemented by adding an indicator variable to the indirect utility equation that equals one for MillerCoors brands post-merger. Doing so does not affect our elasticity estimates.

⁴⁰While the instruments based on the indicators for ABI and MillerCoors brands in the post-merger periods are novel, they are easily motivated from the supply-side of the model. Validity hinges on the assumption that unobserved quality does not change differentially for ABI and MillerCoors.

Table 3: Demand-Side Estimates

Regressor	Parameter	OLS	2SLS	RCLM
Retail Price	α	-0.266*** (0.067)	-0.355*** (0.076)	-0.458*** (0.104)
<i>RCLM Interactions</i>				
Income \times Constant	Π_1			-0.294*** (0.080)
Income \times Import	Π_2			0.281* (0.155)
<i>Derived Statistics</i>				
Median Price Elasticity		-2.68	-3.57	-4.13
Frequency of Inelastic Demand		0.001%	0%	0%
1st Stage F -Statistic			26.09	
GMM J -Statistic				18.89

Notes: The table shows the results of demand-side estimation. There are 53,543 observations at the product-period-region level. The sample spans 39 regions over 2005-2011, excluding the months between June 2008 and May 2009. All regressions include product, region, and period fixed effects. The logit model is estimated alternatively with OLS and 2SLS. The RCLM is estimated with 200 income draws for each region-period. Standard errors clustered by region and are shown in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

6 Results

6.1 Demand Estimates

Table 3 presents the results of demand-side estimation. The first two columns show the results of logit demand estimation, conducted with OLS and 2SLS, respectively. The dependent variable in these regressions is $\log(s_{jm}) - \log(s_{0m})$. The third column shows results from the RCLM, which we estimate using 200 income draws for each region-period combination. The RCLM specification allows consumer income to affect preferences for the inside goods and preferences for imported brands (i.e., the Corona and Heineken products). All regressions include product, region, and period fixed effects. Estimation is based on 53,543 observations at the product-period-region level. The sample spans 39 regions over 2005-2011, excluding months between June 2008 and May 2009. Standard errors are clustered at the region-level to account for correlations among observations from the same region.

The price coefficient becomes more negative as we use instrumental variable techniques relative to OLS, suggesting that beer prices are set by firms with knowledge of preferences not captured by our fixed effects. The instruments are powerful as demonstrated by the

first stage F -statistic of 26.09 that we obtain from the 2SLS regression.⁴¹ With 2SLS and RCLM, products are never priced on the inelastic portion of the demand curve, and the median demand elasticity in our full RCLM specification is -4.13 .⁴² The RCLM results also indicate that income (i) reduces preferences for the inside goods, and (ii) increases preferences for imported brands. Both effects are statistically significant.⁴³

The RCLM demand specification, while parsimonious, produces substitution patterns that are reasonable on a number of important dimensions. First, it breaks the IIA property of logit demand as it pertains to substitution between imported and domestic brands. For instance, median consumer diversion from Bud Light to Miller Lite is roughly six times larger than diversion from Bud Light to Corona Extra, well exceeding what would be predicted on the basis of market shares alone.⁴⁴ Second, it produces a greater willingness-to-pay for supermarket beer due to the onset of recession, but only for cheaper domestic brands of ABI and MillerCoors. This likely reflects substitution from wine and restaurants/bars, both of which are in the outside good. This demand shift is moderated by a secular decline in willingness-to-pay for the inside goods that is captured through the period fixed effects.

To illustrate how demand changes over the sample period, we conduct a counter-factual experiment in which we calculate market shares under the assumption that the price of each product is at its mean level in all markets. This shuts down supply-side pricing reactions completely. Figure 2 shows the results for Bud Light and Corona Extra 12-packs. The market shares of both products decrease over the sample period, but this is attenuated in later years for Bud Light due to macroeconomic effects. The secular decline in market shares relative to the outside good is driven by the period fixed effects, which we plot in Appendix Figure C.1, and could be driven by changing preferences for craft beer and wine, or by

⁴¹The partial F -statistic is adjusted using a clustering correction at the region level.

⁴²Appendix Table C.1 shows median own-price and cross-price elasticities of demand for 12-packs of beer. The median own-price elasticities are highest for Corona and Heineken Light, at -6.27 and -6.32 respectively, and lowest for Miller High Life, at -3.37 . Overall, the own-price elasticities are somewhat greater than the own-price elasticities reported in Romeo (2014), and somewhat smaller than the own-price elasticities reported in Hellerstein (2008). Most comparable are the elasticities of Slade (2004) and Pinske and Slade (2004), obtained for the U.K. beer industry.

⁴³The RCLM has eight overidentifying restrictions. Asymptotically, the minimized GMM objective function should follow a Chi-square distribution with eight degrees of freedom under the null hypothesis that each moment is valid. The minimized objective function value of 18.89 just exceed the .05 critical value of 16, so there is some basis for rejecting the model. That said, existing Monte Carlo evidence indicates that this test over-rejects in finite samples (Altonji and Segal (1996)).

⁴⁴The statistic reported is for 12-packs. Diversion from product A to product B is defined as the fraction of unit sales lost by the product A, due to a price increase, that are diverted to product B. Appendix Table C.2 contains a matrix of median diversion ratios for 12-packs. Diversion from Bud Light 12-packs to Miller Lite 12-packs is 0.045, and diversion from Bud Light 12-packs to Corona Extra 12-packs is 0.008. The table does not incorporate substitution to 24-packs. The average diversion to the outside good is 31 percent.

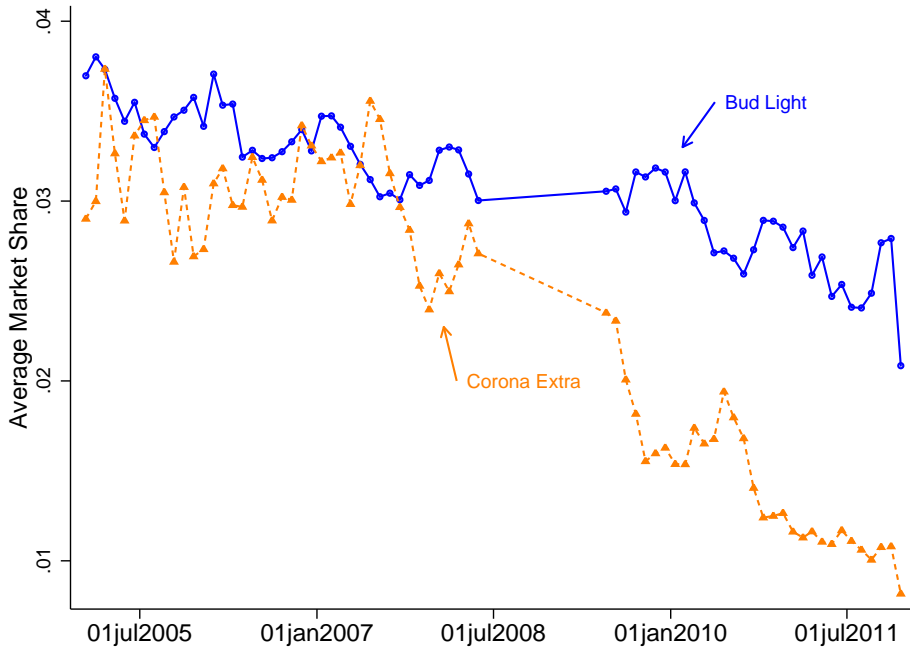


Figure 2: Counter-Factual Market Share Predictions

Notes: The figure uses the estimated demand system to plot the market share of Bud Light and Corona Extra 12-packs throughout the sample period, under the counterfactual assumption that all products are constantly priced at their mean level. Market shares are averaged across the 39 regions.

other considerations that are outside the model. These patterns are in contrast to the raw data, which indicate that the unit sales of Bud Light decrease after the Miller/Coors merger relative to the unit sales of Corona Extra. We revisit this topic in Section 7.

6.2 Supply Estimates

Table 4 presents the results of supply-side estimation. The four columns differ only in how the retail scaling parameter is treated: in column (i) the retail parameter is estimated, while in columns (ii)-(iv) it is normalized to 0.00, 0.25, and 1.00, respectively. All regressions incorporate product, region, and period fixed effects into the marginal cost function. The results from the RCLM demand-side estimation are taken as given. Again estimation is based on 53,543 observations at the product-period-region level. Standard errors are clustered at the region-level to account for correlations among observations from the same region.

The brewer collusion parameter is positive and statically significant in each specification, ranging from 0.32 to 0.38. The results easily reject Nash-Bertrand pricing in the post-merger periods. Strictly interpreted, the parameter indicates that ABI and MillerCoors

Table 4: Supply Side Estimates

Regressor	Parameter	(i)	(ii)	(iii)	(iv)
<i>Nonlinear Parameters</i>					
Brewer Collusion	κ	0.330*** (0.092)	0.327*** (0.096)	0.336*** (0.087)	0.381*** (0.090)
Retail Scaling	λ	0.068 (0.100)	0 -	0.25 -	1 -
<i>Linear Parameters</i>					
MillerCoors×PostMerger	γ_1	-0.557*** (0.084)	-0.506*** (0.111)	-0.616*** (0.114)	-0.739** (0.319)
MillerCoors×PostMerger ×24-Pack	γ_2	-0.321*** (0.061)	-0.324*** (0.086)	-0.318*** (0.065)	-0.301*** (0.085)
Distance	γ_3	0.167*** (0.062)	0.170*** (0.070)	0.161*** (0.081)	0.115*** (0.151)
Distance×24-Pack	γ_4	0.018 (0.039)	0.007 (0.051)	0.029 (0.050)	0.088 (0.086)
<i>Derived Statistics</i>					
Negative Marginal Costs		1.28%	0.54%	11.99%	70.94%
GMM <i>J</i> -Statistic		29.37	30.03	29.50	29.40

Notes: The table shows the results of supply-side GMM estimation. There are 53,543 observations at the product-period-region level. The sample spans 39 regions over 2005-2011, excluding the months between June 2008 and May 2009. Distance is measured as thousands of miles between the brewery and region, interacted with the retail price of gasoline. All regressions also include product, region, and period fixed effects. The retail scaling parameter is estimated in column (i) and normalized in columns (ii)-(iv). The standard errors, shown in parentheses, are clustered by region and adjusted for demand-side estimation. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

internalize roughly a third of the other's profits when pricing in the post-merger periods. In our view, however, the looser interpretation of increased tacit collusion between ABI and MillerCoors is closer to what can be supported by the data, given the normalization that pre-merger competition is Nash-Bertrand. The inference of increased coordination does not depend on the treatment of the retail scaling parameter, and is robust with a perfectly competitive retail sector (column (ii)), a monopolist retailer (column (iv)), and intermediate levels of retail market power (columns (i) and (iii)).

The estimated retail scaling parameter takes a value of 0.068. The precision of the point estimate is sufficient to reject retail monopoly but not perfect retail competition. The economic implications of a small retail scaling parameter are that (i) retail markups on beer

are modest, and (ii) retail pass-through is close to the identity matrix.⁴⁵ This result could be driven by either by significant retail competition in the beer category, or by vertical arrangements that successfully mitigate double marginalization, such as implicit maximum retail price maintenance. Nearly all of the price observations can be rationalized with nonzero marginal costs under the estimated retail scaling parameter. The ability of the model to rationalize prices in this way deteriorates with the magnitude of retail market power, and less than 30% of the observations yield positive marginal costs with retail monopoly.

Turning to the marginal cost shifters, the parameters for MillerCoors products in the post-merger periods are negative, and the distance parameter is positive, consistent with the existence of transportation costs. This supports two channels through which the Miller/Coors merger produced marginal cost reductions. First, the merger lowered the level of MillerCoors marginal cost curves by \$0.56 for 12-packs and \$0.89 for 24-packs. Second, it reduced the shipping distance between breweries and retailers. The latter channel is particularly meaningful from the Coors products. We calculate that the two sources of efficiencies imply an average reduction in the marginal cost of 12-pack Coors products of 0.76 in the year 2011. The comparable average marginal cost during this period would have been \$5.55 but for the efficiencies, implying marginal cost savings of 13.6 percent. This number is close to, but slightly higher than, the 11 percent reduction in unit cost predicted in the trade press (e.g., van Brugge et al (2007)).⁴⁶

Table 5 shows the average pre-merger and post-merger markups on ABI, Coors, and Miller 12-packs, separately at the brewer and retail level. Markups are calculated based on equation (6) and the baseline parameter estimates. As shown, the brewer markup on ABI brands increases from \$3.97 pre-merger to \$4.97 post-merger. This reflects, in part, post-merger tacit collusion. The brewer markup increases are even larger for Coors (\$2.97 to \$4.89) and Miller (\$3.63 to \$5.27) due to the combined impact of collusion and cost savings. The retail markup is around \$0.80-\$0.90 before and after the merger.

Figure 3 provides another way to visualize the impact of the Miller/Coors merger on markups. The four scatterplots have imputed marginal costs on the horizontal axis and retail prices on the vertical axis, separately for Miller Lite, Coors Light, Bud Light, and Budweiser. Observations are calculated as region-specific 12-pack averages. Pre-merger data from 2007 are plotted as blue circles and post-merger data from 2009 are plotted as red plus signs. Corresponding lines of best fit also are plotted. The key empirical pattern is that

⁴⁵A product-specific brewer price change results in nearly complete retail pass-through, and does not affect much other retail prices because cross pass-through is nearly zero.

⁴⁶We plot the period fixed effects in Appendix Figure C.1.

Table 5: Average Markups by Firm

	ABI	Coors	Miller
Pre-Merger Brewer Markup	3.97	2.97	3.63
Post-Merger Brewer Markup	4.79	4.89	5.27
Pre-Merger Retail Markup	0.86	0.85	0.91
Post-Merger Retail Markup	0.83	0.82	0.91

Notes: The table presents volume-weighted average markups for 12-packs of beer, separately for the brands of ABI, Coors, and Miller. Markups are calculated based on the supply-side model. The pre-merger data span January 2005 to May 2008, while the post-merger data span June 2009 to December 2011. ABI brands include Budweiser and Bud Light, the Coors brands include Coors Light and Coors, and the Miller brands include Miller Genuine Draft, Miller High Life, and Miller Lite.

post-merger prices are above pre-merger prices, for any given level of costs. This cannot be explained by demand changes because demand for these products decreases over the sample period. Instead, the causes are the internalization of competition between Miller and Coors, and the rise of coordination between MillerCoors and ABI.⁴⁷

Figure 4 explores further the marginal cost reductions. Shown are two scatterplots, one each for Coors Light and Miller Lite. Each dot is an average within a region, in the year 2011. The horizontal axis is the magnitude of the merger-induced marginal cost change, reflecting both the reductions in transportation costs and the level effect. The vertical axis is the corresponding change in the retail price. This is not observed explicitly – instead we recompute equilibrium under the counterfactual assumption that the Miller/Coors merger did not generate marginal cost savings, and compare the counterfactual prices to the observed

⁴⁷An empirical pattern of secondary interest is that the relationship between costs and prices appears to weaken in the post-merger period (i.e. cost pass-through decreases). In Appendix Table C.3 we explore that possibility with regression analysis based on observations at the product-period-region level, and find statistically significant evidence of reduced cost pass-through with Coors Light, Bud Light and Budweiser. This supports the theoretical result of Scharfstein and Sunderam (2013) that reduced cost pass-through can be taken as evidence of tacit collusion, all else equal. Because the lower post-merger pass-through rates are driven by the functional forms used on the demand-side of the model, this also provides an opportunity to conduct a specification check based on reduced-from regressions of prices on marginal cost shifters. We implement using distance between the brewery and region as the cost shifter, but find that the pass-through coefficients are sensitive to the sample and control variables employed.

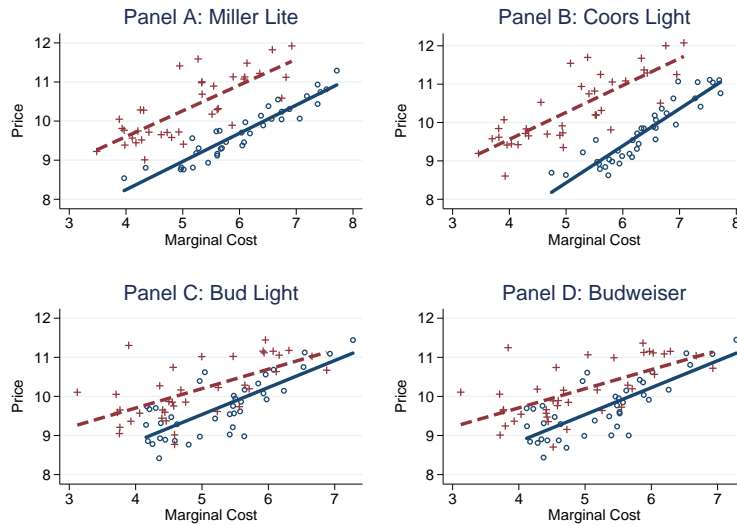


Figure 3: Price-Cost Relationships Pre-Merger and Post-Merger

Notes: The figure provides scatterplots of observed prices and imputed marginal costs for Miller Lite (panel A), Coors Light (panel B), Bud Light (panel C), and Budweiser (panel D). Observations are calculated as region-specific 12-pack averages. Observations from 2007, which pre-date the Miller/Coors merger, are plotted as blue circles. Observations from 2009, which post-date the merger, are plotted as red plus signs. Lines of best fit are provided in each case.

prices. The figures shows that the cost savings on Coors Light range from roughly \$0.60 to \$1.20, depending on the region in question. The greatest cost savings arise in regions, such as San Diego and Los Angeles, that are distant from the original Coors breweries but near a Miller brewery.⁴⁸ The cost savings on Miller Lite have a more limited range, reflecting the more limited scope for reducing costs by moving Miller products nearer to retailers by moving production to the two Coors plants in Golden, CO and Elkton, VA. The figure also shows how these cost savings translate into retail prices, on a region-by-region basis. While these pass-through relationships are driven by the model, the predictions are broadly consistent with the reduced-form results of Ashenfelter, Hosken and Weinberg (2014b).

6.3 Counterfactual simulations

In this section, we explore the effects of the Miller/Coors merger on retail prices, markups, producer and consumer surplus, and welfare. We use counterfactual experiments to isolate the influence of three mechanisms through which the merger changed market outcomes: (i) “unilateral effects” resulting from the internalization of competition between Miller and Coors; (ii) “coordinated effects” resulting from tacit collusion between MillerCoors and ABI;

⁴⁸The production of Coors beer for San Diego and Los Angeles moved from Golden Colorado to Irwindale California, reducing shipping distances by 946 and 987 miles, respectively.

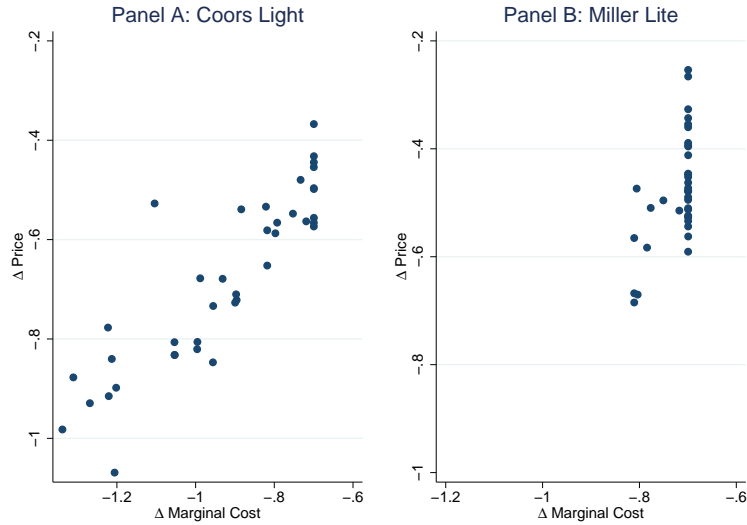


Figure 4: Change in Price against Change in Marginal Cost

Notes: The figure plots average regional difference in price against average regional difference in marginal cost for Coors Light (Panel A) and Miller Lite (Panel B).

and (iii) marginal cost reductions from the merger efficiencies. What is observed directly, through the data and the model estimates, is the scenario in which the Miller/Coors merger occurs with coordinated effects and cost reductions. To support the analysis, we recompute equilibrium under four counterfactual scenarios:

- The merger does not occur.
- The merger occurs with efficiencies and without coordinated effects.
- The merger occurs without efficiencies and without coordinated effects.
- The merger occurs without efficiencies and with coordinated effects.

We compare outcomes across these scenarios to identify the merger effects and explore the three mechanisms.⁴⁹ We begin with price graphs, which provide a transparent representation of the data and the counterfactual simulations.

⁴⁹For the counterfactuals without efficiencies, we calculate the marginal costs of the Miller and Coors products as if there were no level-effects of the merger on marginal costs (i.e., $\gamma_1 = \gamma_2 = 0$), and products were brewed at their original breweries. For the counterfactuals without coordinated effects, we set the brewer collusion parameter to zero (i.e., $\kappa = 0$). For the scenario in the merger does not occur, we do both of the above and also adjust the ownership matrix (i.e., Ω) to reflect independent ownership of the Miller and Coors products in the post-merger periods.

Figure 5 shows the evolution of average retail prices for Coors Light 12-packs under each of the scenarios.⁵⁰ The five data series shown, which correspond to the counterfactual scenarios enumerate above, diverge in the post-merger periods. Several conclusions are immediate. The Miller/Coors merger increases the prices of Coors Light substantially. This is apparent by comparing the raw data, which are shown in red and labeled “Coordinated, Unilateral, Efficiencies,” to the simulated prices that arise without the merger, which are shown in gold and labeled “No Merger.” Because the simulations predict that retail prices would have decreased but for the merger, the total effect of the merger on Coors Light retail prices exceeds what we estimate with the reduced-form regressions.⁵¹

Tacit collusion effects account for most of this price increase. Absent coordination between ABI and MillerCoors, unilateral effects and marginal cost efficiencies generate prices (shown as the blue “Unilateral, Efficiencies” series) that are close to those that arise without the merger. The simulations also confirm that the merger has a meaningful impact on unilateral pricing incentives. When this mechanism is isolated, the resulting prices (shown as the green “Unilateral, No Efficiencies” series) are closer to the raw data than the prices that arise without the merger. The magnitudes of these price elevations resulting from unilateral effects are counter-balanced by lower marginal costs, as anticipated by DOJ. Lastly, while the observed prices in the post-merger periods well exceed the simulated prices that arise without the merger, they are higher still without efficiencies (shown as the black “Coordinated, Unilateral, No Efficiencies” series).⁵²

Figure 6 shows the evolution of average retail prices for Bud Light 12-packs under the five scenarios. Once again, the observed prices in the post-merger periods exceed substantially the prices that arise in the “No Merger” baseline. The price elevation is due exclusively to coordinated effects. This can be seen by examining the “Unilateral, Efficiencies” scenario, which tracks the “No Merger” baseline nearly exactly. While our evidence indicates that the unilateral effects of the Miller/Coors merger are substantial (though substantially offset by efficiencies), these unilateral effects have a comparatively small impact on Bud Light prices. Further, the marginal cost efficiencies of the merger, which affect ABI only indirectly, also have a small impact on Bud Light prices.⁵³

⁵⁰Each dot represents the average price across the 39 regions in a specific period.

⁵¹We return to this observation shortly. That prices would have decreased without the merger is driven largely by the period fixed effects, which soak up empirical variation related to decreases in sales volume (on the demand-side) and lower prices of the Modelo and Corona brands (on the supply-side).

⁵²Appendix Figure C.2 shows that the same empirical patterns arise for Miller Lite, albeit with a somewhat smaller impact of the marginal cost efficiencies.

⁵³Appendix Figure C.3 shows that the same empirical patterns arise for Budweiser.

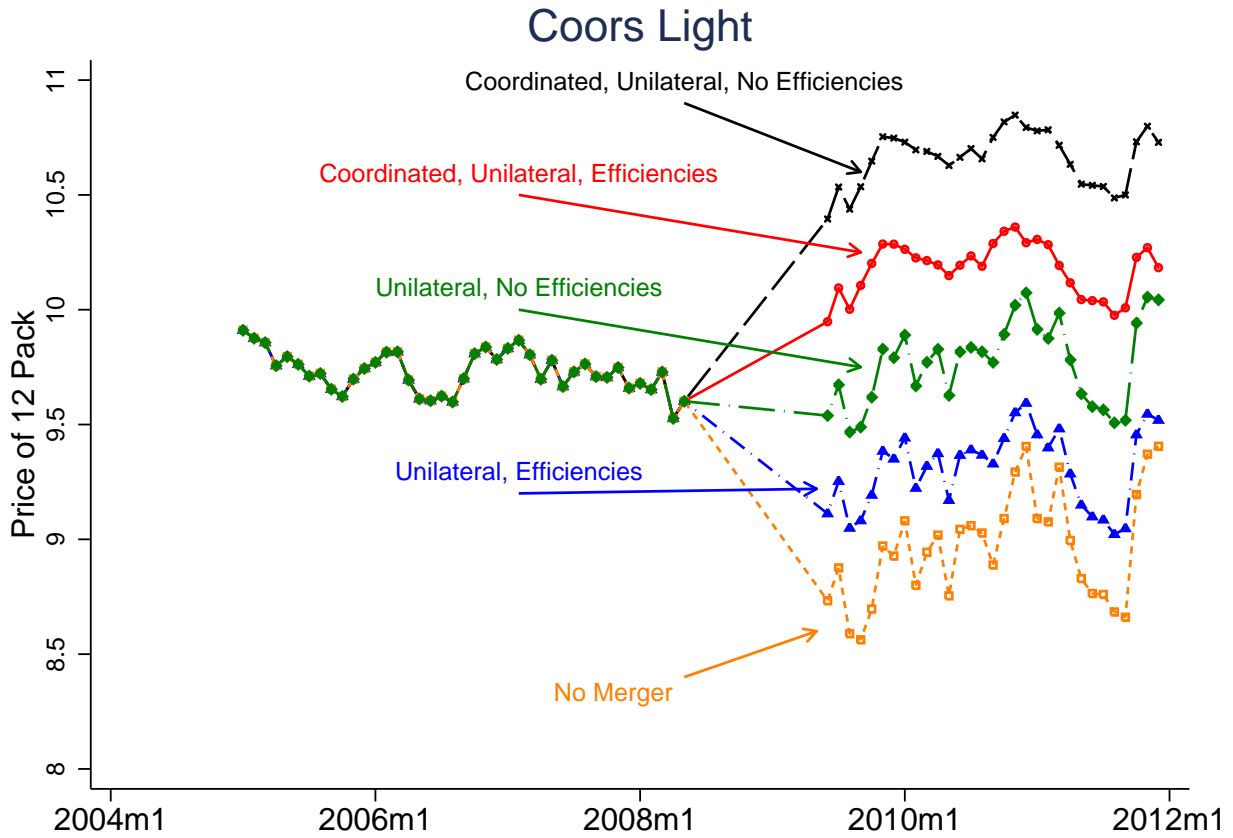


Figure 5: Counterfactual Price Series for Coors Light

Notes: The figure plots the average retail prices of Coors Light 12-Packs. The red prices labeled “Coordinated, Unilateral, Efficiencies” are the raw data. The gold prices labeled “No Merger” are numerically computed for a counterfactual in which to Miller/Coors merger does not occurs. The blue prices labeled “Unilateral, Efficiencies” are the scenario in which the Miller/Coors merger occurs with unilateral effects and efficiencies but no coordinated effects. The green prices labeled “Unilateral, No Efficiencies” are the scenario in which the merger occurs with unilateral effects but without efficiencies or coordinated effects. The black prices labeled “Coordinated, Unilateral, No Efficiencies” are computed assuming the merger occurs with coordinated and unilateral effects but without efficiencies. Straight averages are calculated over the 39 regions in the data.

Table 6 provides the mean retail prices and markups of ABI, Miller, and Coors brands, across each of the five scenarios. All numbers are for 2011, the final year of the sample. The mean prices are consistent with the figures discussed above. For instance, comparing columns (i) to (v) indicates that the Miller/Coors merger caused ABI 12-pack retail prices to increase from \$9.13 to \$10.09, Miller 12-pack prices to increase from \$7.59 to 8.96, Coors 12-pack prices to increase from \$8.61 to \$10.20. In percentage terms these effects are quite large: 9.5% for ABI and 18% for both Miller and Coors. The increase in the ABI markup reflects the higher retail price. The increases in the Miller and Coors markups are more pronounced and also reflect the marginal cost savings of the merger.

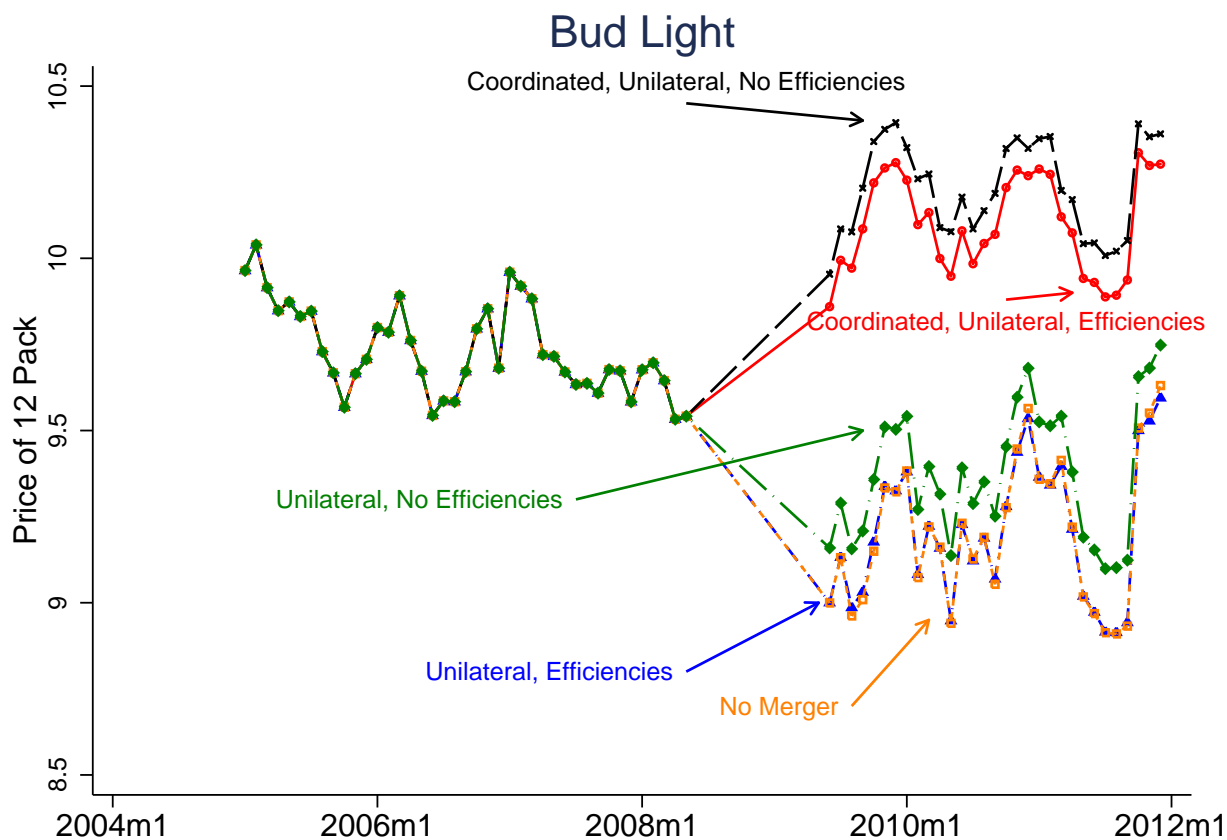


Figure 6: Counterfactual Price Series for Bud Light

Notes: The figure plots the average retail prices of Bud Light 12-Packs. The red prices labeled “Coordinated, Unilateral, Efficiencies” are the raw data. The gold prices labeled “No Merger” are numerically computed for a counterfactual in which to Miller/Coors merger does not occurs. The blue prices labeled “Unilateral, Efficiencies” are the scenario in which the Miller/Coors merger occurs with unilateral effects and efficiencies but no coordinated effects. The green prices labeled “Unilateral, No Efficiencies” are the scenario in which the merger occurs with unilateral effects but without efficiencies or coordinated effects. The black prices labeled “Coordinated, Unilateral, No Efficiencies” are computed assuming the merger occurs with coordinated and unilateral effects but without efficiencies. Straight averages are calculated over the 39 regions in the data.

Table 7 shows welfare statistics across the five scenarios for the 2011 calendar year. All numbers shown are percentage differences relative to the “No Merger” counterfactual in which the Miller/Coors merger does not occur.⁵⁴ We begin with producer surplus. A number of results are noteworthy. The merger increases producer surplus across the board. If the merger causes unilateral effects, coordinated effects, and efficiencies (as we estimate), then total producer surplus increases 33.7% relative to the no merger baseline. More than half of these gains are due to tacit collusion. For ABI specifically, nearly all the gains are

⁵⁴Percentage differences are more illuminating than level effects because our data reflect a subsample of national sales. Appendix Table C.4 shows the level effects – though it is not apparent (to us) how to scale these level effects in a satisfactory manner.

Table 6: Prices and Markups in Counterfactual Scenarios

	(i)	(ii)	(iii)	(iv)	(v)
<i>Scenario Description</i>					
Coordinated Effects	yes	yes	no	no	no
Unilateral Effects	yes	yes	yes	yes	no
Efficiencies	yes	no	yes	no	no
<i>Retail Prices</i>					
ABI	10.05	10.17	9.07	9.25	9.13
Miller	8.97	9.19	7.98	8.21	7.59
Coors	10.20	10.67	9.29	9.75	8.61
<i>Brewer Markups</i>					
ABI	4.79	4.93	3.77	3.93	3.74
Miller	5.27	5.06	4.26	3.90	3.16
Coors	4.90	4.66	3.89	3.63	2.76

Notes: The table provides volume-weighted mean markups, separately for the 12-pack brands of ABI, Miller, and Coors, under five different economic scenarios. The first scenario, that of column (i), is based on the supply-side parameter estimates. Columns (ii)-(v) show results counterfactual scenarios. The numbers in column (ii) are computed assuming the merger occurs with coordinated and unilateral effects but without efficiencies. The numbers in column (iii) are computed assuming the merger occurs with unilateral effects and efficiencies but no coordinated effects. The numbers in column (iv) are computed assuming the merger occurs with unilateral effects but without efficiencies or coordinated effects. Lastly, the numbers in column (v) are computed assuming that the Miller/Coors merger does not occur. All statistics are for 2011, the final year of our sample.

due to tacit collusion. Marginal costs efficiencies account for a 4%-5% increase in industry-wide producer surplus. These efficiencies both raise the surplus of MillerCoors and lower the surplus of ABI (due to lower MillerCoors prices). The former effect dominates the latter.

We turn now to consumer surplus and total surplus. The merger makes consumers unambiguously worse in each of the scenarios considered. If the merger causes unilateral effects, coordinated effects, and efficiencies (as we estimate), then total consumer surplus decreases 13.6% relative to the no merger baseline. However, the magnitude of this impact varies substantially with the roles of tacit collusion and efficiencies. If the merger causes only unilateral effects then consumer surplus loss is 4.0%, and layering on marginal cost efficiencies further reduces this loss to only 1.2%. This may well have been the scenario deemed most likely by the DOJ in its decision to clear the merger. Lastly, we observe that even with tacit collusion, the marginal cost efficiencies are sufficiently large that the producer surplus gains outweigh the consumer surplus losses, such that the merger increases total surplus by

Table 7: Welfare Effects of Miller/Coors Merger

	(i)	(ii)	(iii)	(iv)	(v)
<i>Scenario Description</i>					
Coordinated Effects	yes	yes	no	no	no
Unilateral Effects	yes	yes	yes	yes	no
Efficiencies	yes	no	yes	no	no
<i>Merger Effect on Producer Surplus</i>					
ABI	19.4%	32.1%	1.2%	12.9%	.
Miller	53.3%	23.7%	28.9%	12.9%	.
Coors	62.2%	34.5%	38.2%	5.5%	.
Total Industry	33.7%	28.7%	14.3%	10.6%	.
<i>Merger Effect on Consumer Surplus</i>					
Total Industry	-13.6%	-17.8%	-1.2%	-6.1%	.
<i>Merger Effect on Total Surplus</i>					
Total Industry	2.1%	-2.3%	4.0%	-0.6%	.

Notes: The table provides the effect of the Miller/Coors merger on producer surplus, consumer surplus, and total surplus. All numbers are reported as the percentage change, relative to the “No Merger” scenario in which the Miller/Coors merger does not occur, and are for the year 2011. Column (i) considers the scenario in which the merger occurs with coordinated effects, unilateral effects, and efficiencies. This best reflects the raw data. Column (ii) considers the counterfactual scenario in which the merger occurs with coordinated and unilateral effects but without efficiencies. Column (iii) considers the counterfactual scenario in which the merger occurs with unilateral effects and efficiencies but no coordinated effects. Column (iv) considers the counterfactual scenario in which the merger occurs with unilateral effects but without efficiencies or coordinated effects. No numbers are shown for column (v), which represents the baseline scenario in which no merger occurs.

2.1%. Thus, clearance of the merger could be justified on a total welfare standard despite its ramifications for retail prices and consumer surplus. Absent tacit collusion, total surplus increases even more because the smaller increase in retail prices leads to a smaller impact on deadweight loss.

7 Alternative Explanations

The core econometric result presented above is that emergent tacit coordination between MillerCoors and ABI rationalizes the observed retail price data. This flows from a number of reasonable restrictions on the economic environment, and is corroborated by qualitative evidence generated by MillerCoors and ABI in the normal course of business. In this section,

we address a number of alternative explanations that theoretically could explain why the retail prices of ABI and MillerCoors increase relative to those of Modelo and Heineken. Explanations that generate absolute price increases but not (obvious) relative effects, such as increases in retail market power, are not considered.

7.1 ABI marginal costs

We assume for the purposes of estimation that the unobserved marginal costs of ABI products do not change, relative to those of Grupo Modelo and Heineken, in the post-merger periods. If this assumption is invalid, and specifically if ABI becomes relatively more expensive to produce and sell in the post-merger periods, then the estimator could mistake unilaterally profitable pricing behavior on the part of ABI as evidence of tacit collusion.

The documentary record provides little support for the notion of higher costs. The acquisition of Anheuser-Busch by Inbev in 2009 was motivated in part by cost savings. To these extent that savings were realized, and affected marginal cost, our estimate of brewer collusion would be conservative. It would take even more coordination to achieve the observed price points. We understand, however, that any cost savings due to the Anheuser-Busch acquisition were small, involving only best practices, because distribution was unaffected for the brands in our sample and there is little indication of realized savings in the ABI annual reports that postdate the acquisition.⁵⁵

Further, we calculate that ABI marginal cost increases of roughly \$0.55 per 12-pack, relative to the pre-merger periods, would be required to drive the collusion parameter to zero.⁵⁶ This is large relative to the average pre-merger marginal costs for ABI that we impute from the baseline model (e.g., \$5.22 per 12-pack), and of a similar magnitude to the total marginal cost synergies that we estimate for the Miller/Coors merger (e.g., see Figure 4). Effects at that level as unlikely to pass without notice in the annual reports of ABI and the popular press. We cannot rule out more modest marginal cost increases, but those would be insufficient to fully explain the observed price increases.

⁵⁵Inbev motivated the acquisition as a source of substantial fixed cost savings. It subsequently revised the pay system, ended pension contributions and life insurance for retirees, and transferred the foreign beer operations of Anheuser Busch to InBev (Ascher (2012)).

⁵⁶The exercise is in the spirit of Werden (1996). We assume that brewer competition is Nash Bertrand in the post-merger periods, taking as given the demand parameters and the baseline estimate of the retail scaling parameter. We then impute marginal costs from equations (5) and (6). The average post-merger marginal costs for ABI that arise in the baseline specification (i.e., with collusion) are \$4.76 per 12-pack.

7.2 Demand for ABI products

We assume, again for the purposes of estimation, that the unobserved qualities of ABI products do not change relative to those of the Grupo Modelo and Heineken. If there is a relative increase in willingness-to-pay for ABI products in our sample, beyond what is captured in the model, then once again the estimator could mistake unilaterally profitable pricing behavior on the part of ABI as evidence of tacit collusion. The most obvious source of relative demand shifts is the Great Recession, which coincides roughly with the Miller/Coors merger. The model incorporates substitution toward cheaper domestic brands in response to adverse income shocks. Thus, for the recession to produce a spurious inference of tacit collusion what is required is another factor (e.g., wealth) that is impacted by macroeconomic conditions, imperfectly correlated with income, and associated with demand for cheaper beer. We cannot rule out such effects on purely on theoretical grounds.

The empirical support for an expansion of ABI demand is negative, however. The unit sales of ABI products *decrease* relative to the products of Grupo Modelo and Heineken after the Miller/Coors mergers, rather than increase as would be required under the alternative explanation. To quantify this, we estimate “difference-in-differences” regression equations that contrast the unit sales changes for ABI and Miller/Coors products with those for Grupo Modelo and Heineken products. The baseline regression equation specifies the log unit sales of product j in region r during period t according to

$$\begin{aligned} \log q_{jrt}^R &= \beta_1 \mathbb{1}\{\text{ABI}\}_{jt} \times \mathbb{1}\{\text{Post-Merger}\}_t & (16) \\ &+ \beta_1 \mathbb{1}\{\text{MillerCoors}\}_{jt} \times \mathbb{1}\{\text{Post-Merger}\}_t \\ &+ \beta_2 \mathbb{1}\{\text{Post-Merger}\}_t + \phi_{jr} + \tau_t + \epsilon_{jrt} \end{aligned}$$

which features separate indicator variables for (i) the ABI brands in the post-merger periods, (ii) MillerCoors brands in the post-merger periods, and (iii) all products in the post-merger periods.⁵⁷ We incorporate product fixed effects interacted with region fixed effects, through the parameters ϕ_{jr} , and either a linear time trend or period fixed effects through the parameters τ_t .⁵⁸ Table 8 provides the results. Across all of the specifications and samples, the unit sales of both ABI and MillerCoors decrease after the Miller/Coors merger, both in absolute terms and relative to Grupo Modelo and Heineken. The regression results are corroborated by frequent reference to softening demand conditions in the annual reports of

⁵⁷We take logs of the dependent variable only for ease of interpretation. This does not affect results.

⁵⁸In specifications that include period fixed effects we do not include Post-Merger_t .

Table 8: OLS Regression Results for Log Unit Sales

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
$\mathbb{1}\{\text{ABI}\}$	-0.173***	-0.209**	-0.411***	-0.173***	-0.209**	-0.414***
$\times \mathbb{1}\{\text{Post-Merger}\}$	(0.0466)	(0.0848)	(0.0652)	(0.0468)	(0.0850)	(0.0651)
$\mathbb{1}\{\text{MillerCoors}\}$	-0.0730	-0.158*	-0.344***	-0.0730	-0.158*	-0.347***
$\times \mathbb{1}\{\text{Post-Merger}\}$	(0.0445)	(0.0871)	(0.0672)	(0.0446)	(0.0872)	(0.0673)
$\mathbb{1}\{\text{Post-Merger}\}$	-0.0540	0.0647	0.265***	-	-	-
	(0.0401)	(0.0873)	(0.0701)	-	-	-
Period Fixed Effects	No	No	No	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	No	No	No
# Obs.	25,740	44,621	94,837	25,740	44,621	94,837

Notes: All regressions include product fixed effects interacted with region fixed effects. The dependent variable is the log of unit sales (in 144-ounce equivalent units). Observations are at the product-region-period level. Columns (i) and (iv) contain 12-packs of Bud Light, Coors Light, Miller Lite, Corona Extra, and Heineken. Columns (ii) and (v) contains 12-packs and 24-packs of the same brands. Columns (iii) and (vi) contain 12-pack and 24-packs of these brands plus Budweiser, Coors, Miller Genuine Draft, Miller High Life, Corona Light, and Heineken Premium Light. The estimation sample spans 39 regions from 2001-2011. Standard errors are clustered at the region level and reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

ABI and MillerCoors. For instance, the 2009 ABI Annual Report refers to “an economic environment that was the most difficult our industry has seen in many years” (p. 17).

7.3 Functional form misspecification

The collusion parameter is identified from ABI price changes after the MillerCoors merger. Intuitively, if these price increases are greater than what can be explained under Nash Bertrand competition, given the estimated demand system, then emergent tacit collusion is inferred. Estimates therefore are affected by the degree to which prices are strategic complements. In particular, if the underlying economic reality features strategic complementarity that exceeds the level captured in the RCLM of demand, then we could misinterpret unilaterally optimal price increases for tacit coordination.⁵⁹

Functional form misspecification is unlikely to fully explain our results, however. We

⁵⁹The RCLM is theoretically flexible enough to approximate the curvature of most underlying demand systems, and thus to obtain the correct degree of strategic complementarity. This may not be accomplished in our application due to the parsimonious specification employed.

observe that ABI and MillerCoors prices increase by nearly identical magnitudes following the Miller/Coors merger (e.g. see Figure 1). Thus, for the inference on tacit collusion to be spurious, what is required is for the true economic model to feature price matching behavior in Nash equilibrium. Standard differentiated-products demand systems do not produce anything near that level of strategic complementarity (e.g., Miller, Remer, Ryan and Sheu (2013)). Other modeling frameworks, such as Nash competition on a Hotelling line and differentiated-products Cournot competition, also generate sloped reaction functions and thus fail to generate price matching behavior. An additional hurdle for an explanation based on functional form misspecification is that the prices of Corona and Heineken do not increase after the merger, so if extreme strategic complementarity were to explain the results, it would have to exist for the prices of some products and not others.

8 Conclusion

The central result of our research is that emergent tacit collusion explains the observed pattern of retail price increases in the wake of the MillerCoors joint venture. This corroborates allegations made by the DOJ in its Complaint to enjoin ABI’s attempted acquisition of Grupo Modelo. In developing this result, we estimate a model of price competition that incorporates the possibility of coordination between ABI and MillerCoors. Our identification arguments build on the research of Nevo (1998) and Berry and Haile (2014), and are broadly supported by qualitative evidence. We believe our research to be the first to evaluate the impact of consolidation on tacit collusion, and the first to disentangle the different mechanisms through which mergers affect pricing outcomes. We are also the first, to our knowledge, to estimate a model with a profit-maximizing retail sector that intermediates between consumers and the firms of interest, at least within the framework of the RCLM.

More broadly, our results reinforce that market consolidation can facilitate tacit coordination. This is a well recognized theoretical possibility, and it often receives substantial weight in antitrust enforcement decisions. Yet the empirical literature of industrial organization, for the most part, has not developed a useful set of results and tools that anticipate the coordinated effects of mergers. This is in stark contrast to the progress that has been made in understanding how mergers affect the unilateral pricing incentives of firms (e.g., Deneckere and Davidson (1985); Werden (1996); Nevo (2000a); Jaffe and Weyl (2013)). We view our research as useful first step toward a more sophisticated empirical treatment of coordinated effects.

The main limitation of our approach clarifies the agenda for future research. Namely, we elect not to specify the over-arching supergame, in favor of a model that shows that *some* form of tacit collusion is necessary to rationalize the post-merger pricing data. Thus, our results do not provide specific guidance about how to identify the mergers that pose the greatest risk of facilitating collusion. The challenge for future research is to develop and estimate supergames that are appropriate to specific market contexts. To make this concrete, we offer an illustrative example based on the industry studied here. The documentary evidence we have summarized supports that competition after the Miller/Coors merger could be modeled reasonably as an oligopoly price leadership game. It is straight-forward to show that such a model is not fully identified with the data that are typically available to researchers. An intriguing possibility, one that we are exploring in ongoing research, is that inequality constraints can be employed to partially identify the model. Such research should be of substantial academic interest, and also could help antitrust authorities assess the likelihood that mergers produce tacit collusion in specific market contexts.

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Appendix for Online Publication

A Estimation Details

We estimate the demand-side of the model using the nested fixed point approach of Berry, Levinsohn and Pakes (1995). Our code largely tracks that of Nevo (2000b). Differences arise mainly in the treatment of the contraction mapping, which we compute in C on a market-by-market basis using a tolerance of $1e-14$. This speeds computations by a factor of ten or more when the contraction mapping is spread between three processors. We minimize the objective function using the Nelder-Mead non-derivative search algorithm with a convergence criterion of $1.5e-05$, though parameter estimates are stable across different criteria.

Recent research highlights the estimation challenges that arise because the objective function with RCLM can be highly non-convex and contain multiple local optima and saddle points (e.g., Knittel and Metaxoglou (2012)). We follow a number of recommendations of Knittel and Metaxoglou to ensure that we correctly identify a global minimum of the objective function. First, we use a parsimonious demand specification with only two nonlinear parameters. Second, we pass the optimum obtained with Nelder-Mead to a gradient-based quasi-Newton algorithm and verify that the optimum does not change. Third, we employ a tight tolerance criterion for the contraction mapping. Finally, we confirm the second-order conditions by verifying that the Hessian of the objective function at the optimum is both positive definite and well-conditioned, with eigenvalues equal to 2822 and 257.

Previous articles have highlighted the seasonal nature of beer demand (e.g., Romeo (2014)). While consumption tends to be the highest in the summer and the lowest in the winter, seasonal patterns are region-specific and often are thought to be less pronounced in warmer climates. The period fixed effects we include in estimation can account for average seasonality, but not region-specific seasonality. We use the X-12-ARIMA to deseasonalize beer sales on a region-by-region bases. The X-12-ARIMA algorithm is relied on by the Bureau of Labor Statistics to deseasonalize inputs to the consumer price index.⁶⁰ Appendix Figure A.1 shows results for selected cities. The blue dashed lines are the raw sales data, and the red solid lines represent sales that has been deasonalized with the X-12-ARIMA. The seasonal patterns are clearly distinct across the regions shown (e.g., fluctuations are smaller in Phoenix), in each case the X-12-ARIMA removes the seasonal variation. The

⁶⁰See Makridakis, Wheelwright and Hyndman (1998) and Miller and Williams (2004) for details on the X-12-ARIMA. The program has been used for related purposes in the industrial organization literature (e.g., Langer and Miller (2013)).

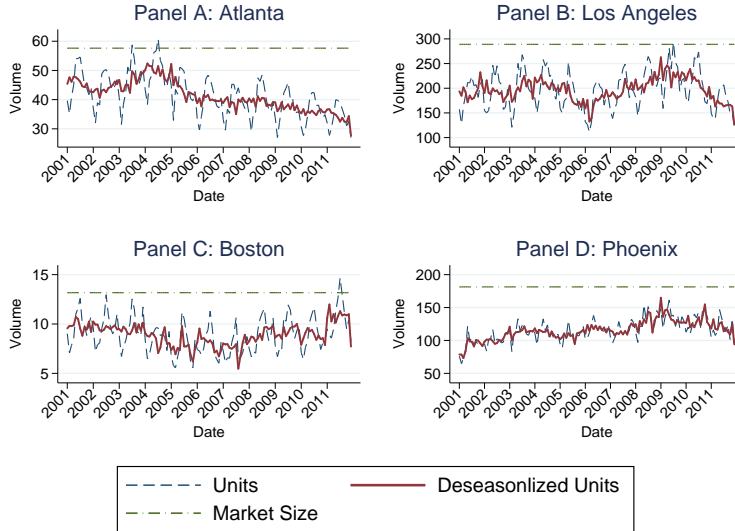


Figure A.1: Beer Consumption in Selected Cities, 2001-2011

Notes: Volume is in 12-pack equivalent units per month. Brands included are Bud Light, Budweiser, Miller Lite, Miller Genuine Draft, Miller High Life, Coors Light, Coors, Corona Extra, Corona Light, Heineken, and Heineken Light. The blue dashed lines are the raw sales data. The red solid lines represent sales that have been deseasonalized with the X-12-ARIMA. The horizontal dashed green lines show the market size used in demand estimation.

green dashed lines shows the market sizes that are used in estimation. The market sizes are calculated as ten percent greater than the maximum level of deseasonalized sales. We believe this treatment of seasonality provides more accurate region-specific predictions than would a reliance on the period effects alone. Nonetheless, the core results are maintained if the X-12-ARIMA is not employed to account for seasonality.

B Supply-Side Standard Error Calculation

The supply-side model of price competition is estimated conditional on the demand parameters obtained from the RCLM. We correct the supply-side standard errors in order to account for the uncertainty present in our demand estimates. The correction is sketched in Wooldridge (2010), although the specific formulation is tailored to our application.

Let $E[g(z_{jm}, \theta_0^S, \theta_0^D)] = 0$ denote a 10 dimensional vector of supply-side moment conditions, where z_{jm} is a vector of instruments for product j in market m , θ_0^S is a 6-dimensional vector of supply-side parameters, and θ_0^D is a 3-dimensional vector of demand-side param-

ters. The first-order conditions of the supply-side GMM objective function are:

$$0 = \left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]_{6 \times 10}^T C_{10 \times 10} \left[g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]_{10 \times 1} \quad (\text{B.1})$$

where C is an estimate of the variance of the supply-side moment conditions, $g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D)$ is the sample analogue of the moment orthogonality conditions, and $J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D)$ is the 10×6 Jacobian matrix of the sample analog moment conditions with respect to the supply-side parameters.

Taking a mean value expansion of $g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D)$ around θ_0^S allows us to rewrite the first-order conditions as:

$$0 = \left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]_{6 \times 10}^T C_{10 \times 10} \left[g(z_{jm}, \theta_0^S, \hat{\theta}^D) \right]_{10 \times 1} + J_{\theta^S} g(z_{jm}, \bar{\theta}^S, \hat{\theta}^D)_{10 \times 6} (\hat{\theta}^S - \theta_0^S)_{6 \times 1} \quad (\text{B.2})$$

Solving for $\hat{\theta}^S - \theta_0^S$ and scaling by the square root of the number of markets M gives the following expression for $\sqrt{M}(\hat{\theta}^S - \theta_0^S)$:

$$- \left[\left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]^T C \left[J_{\theta^S} g(z_{jm}, \bar{\theta}^S, \hat{\theta}^D) \right] \right]^{-1} \left[\left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]^T C \right] \sqrt{M} g(z_{jm}, \theta_0^S, \hat{\theta}^D) \quad (\text{B.3})$$

Now take a mean value expansion of $g(z_{jm}, \theta_0^S, \hat{\theta}^D)$ about θ_0^D .

$$g(z_{jm}, \theta_0^S, \hat{\theta}^D)_{10 \times 1} = g(z_{jm}, \theta_0^S, \theta_0^D)_{10 \times 1} + J_{\theta^D} g(z_{jm}, \theta_0^S, \bar{\theta}^D)_{10 \times 3} (\hat{\theta}^D - \theta_0^D)_{3 \times 1} \quad (\text{B.4})$$

where $J_{\theta^D} g(z_{jm}, \theta_0^S, \bar{\theta}^D)$ is the 10×3 Jacobian matrix of the sample analog moment conditions with respect to the demand-side parameters. The term $(\hat{\theta}^D - \theta_0^D)$ can be rewritten in terms of the sample analog of the demand side moment conditions and the Jacobian of the demand side moment conditions:

$$(\hat{\theta}^D - \theta_0^D) = - \left[\left[J_{\theta^D} h(z_{jm}^D, \hat{\theta}^D) \right]^T A \left[J_{\theta^D} h(z_{jm}^D, \bar{\theta}^D) \right] \right]^{-1} \left[\left[J_{\theta^D} h(z_{jm}^D, \hat{\theta}^D) \right]^T * A \right] h(z_{jm}^D, \hat{\theta}^D) \quad (\text{B.5})$$

where $h(z_{jm}^D, \hat{\theta}^D)$ is the empirical analog of the vector of demand-side moment conditions and A is an estimate of the variance covariance matrix of the demand-side moment conditions. Plugging this into equation (B.3) gives a first-order representation for $\sqrt{M}(\hat{\theta}^S - \theta_0^S)$:

$$\sqrt{M}(\hat{\theta}^S - \theta_0^S) = \left[\left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]^T C^S \left[J_{\theta^S} g(z_{jm}, \bar{\theta}^S, \hat{\theta}^D) \right] \right]^{-1} \left[\left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right]^T C \right] * \sqrt{M} \left(g(z_{jm}, \theta_0^S, \theta_0^D) + J_{\theta^D} g(z_{jm}, \theta_0^S, \bar{\theta}^D) * (\hat{\theta}^D - \theta_0^D) \right) \quad (\text{B.6})$$

A consistent estimate of $Var(\hat{\theta}^S)$ is:

$$\left[G^T C G \right]^{-1} G^T C \Omega C G \left[G^T C G \right]^{-1} \quad (\text{B.7})$$

where

$$\begin{aligned} G &\equiv \left[J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \right] \\ \Omega &= \sum_{m=1}^M (z_m^{S'} \omega_m + F z_m^{D'} \zeta_m) (z_m^{S'} \omega_m + F z_m^{D'} \zeta_m)' \\ F &= J_{\theta^D} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D) \left[\left[J_{\theta^D} h(z_{jm}^D, \hat{\theta}^D) \right]^T C^D \left[J_{\theta^D} h(z_{jm}^D, \hat{\theta}^D) \right] \right]^{-1} \left[\left[J_{\theta^D} h(z_{jm}, \hat{\theta}^D) \right]^T C^D \right] \end{aligned}$$

The Jacobians of the supply side moments $J_{\theta^D} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D)$ and $J_{\theta^S} g(z_{jm}, \hat{\theta}^S, \hat{\theta}^D)$ were approximated by one-sided finite differences with perturbation factor $1e^{-10}$.

C Additional Tables and Figures

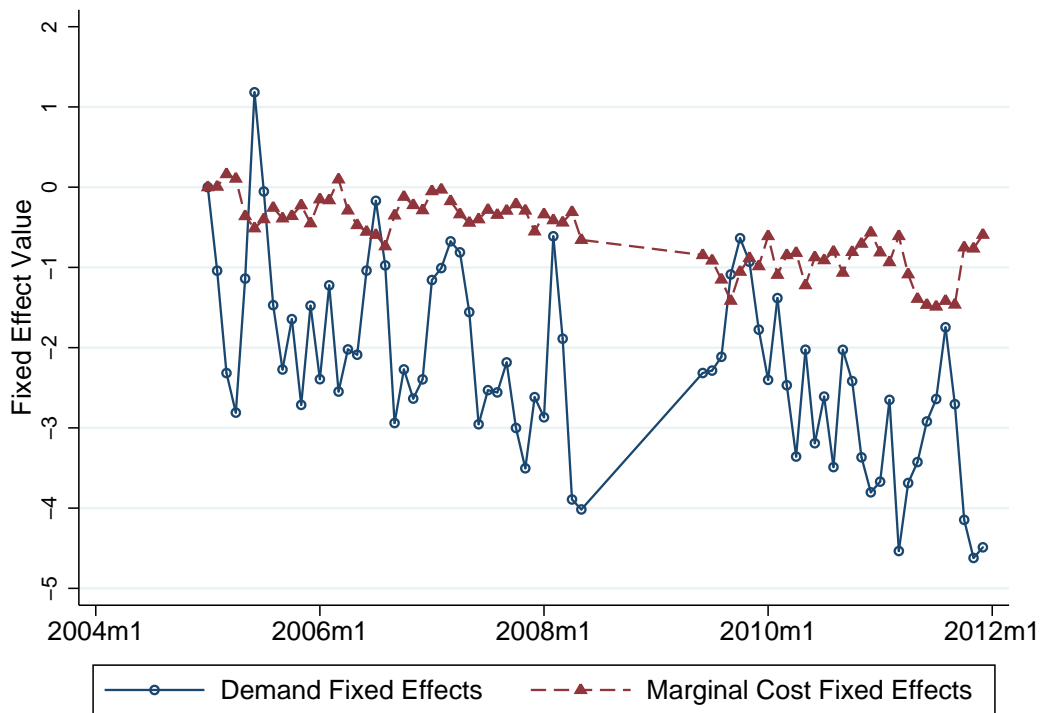


Figure C.1: Estimated Demand-Side and Marginal Cost Period Fixed Effects

Notes: The figure plots the estimated period fixed effects that affect preferences for the inside good (on the demand-side) and the marginal costs of all products (on the supply-side). We divide the period fixed effects by the absolute value of the demand-side price coefficient, prior to plotting, so that the units are in dollars.

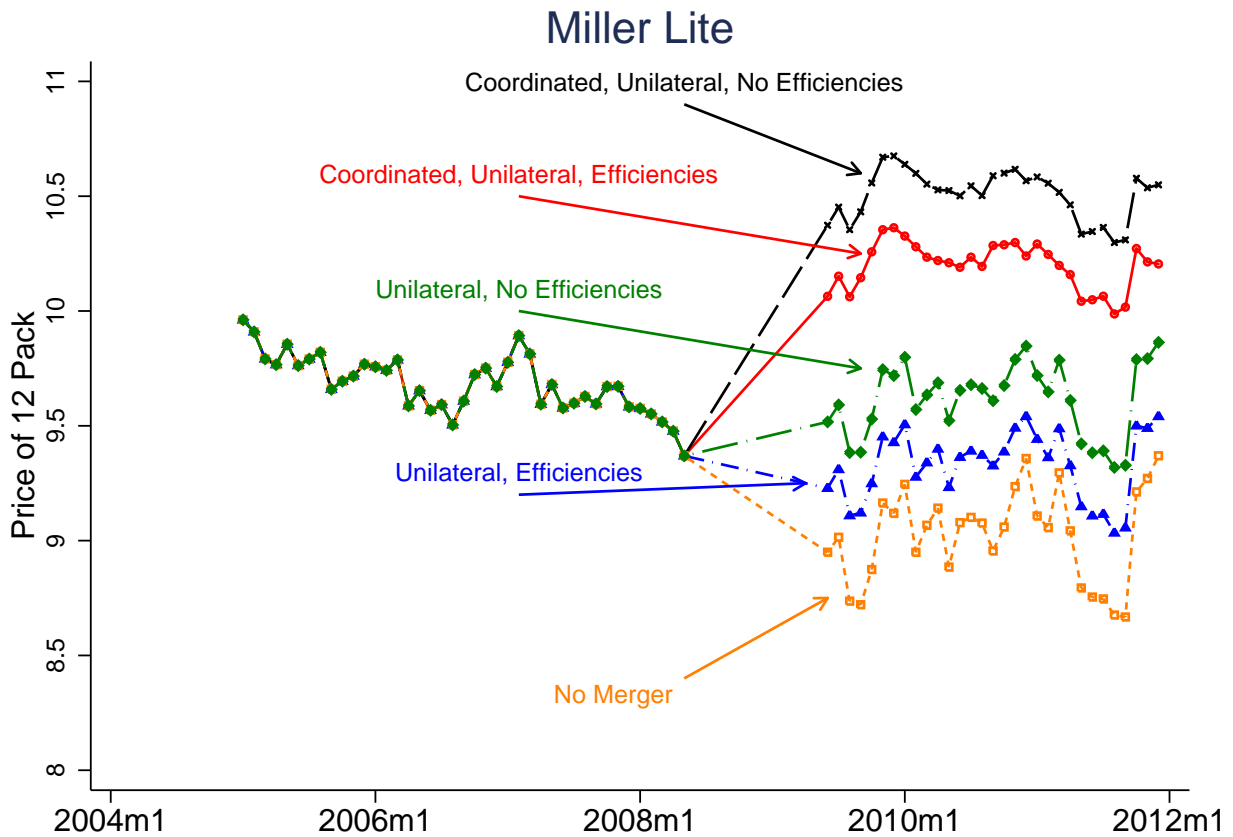


Figure C.2: Counterfactual Price Series for Miller Lite

Notes: The figure plots the average retail prices of Miller Lite 12-packs. The red prices labeled “Coordinated, Unilateral, Efficiencies” are the raw data. The gold prices labeled “No Merger” are numerically computed for a counterfactual in which the Miller/Coors merger does not occur. The blue prices labeled “Unilateral, Efficiencies” are the scenario in which the Miller/Coors merger occurs with unilateral effects and efficiencies but no coordinated effects. The green prices labeled “Unilateral, No Efficiencies” are the scenario in which the merger occurs with unilateral effects but without efficiencies or coordinated effects. The black prices labeled “Coordinated, Unilateral, No Efficiencies” are computed assuming the merger occurs with coordinated and unilateral effects but without efficiencies. Straight averages are calculated over the 39 regions in the data.

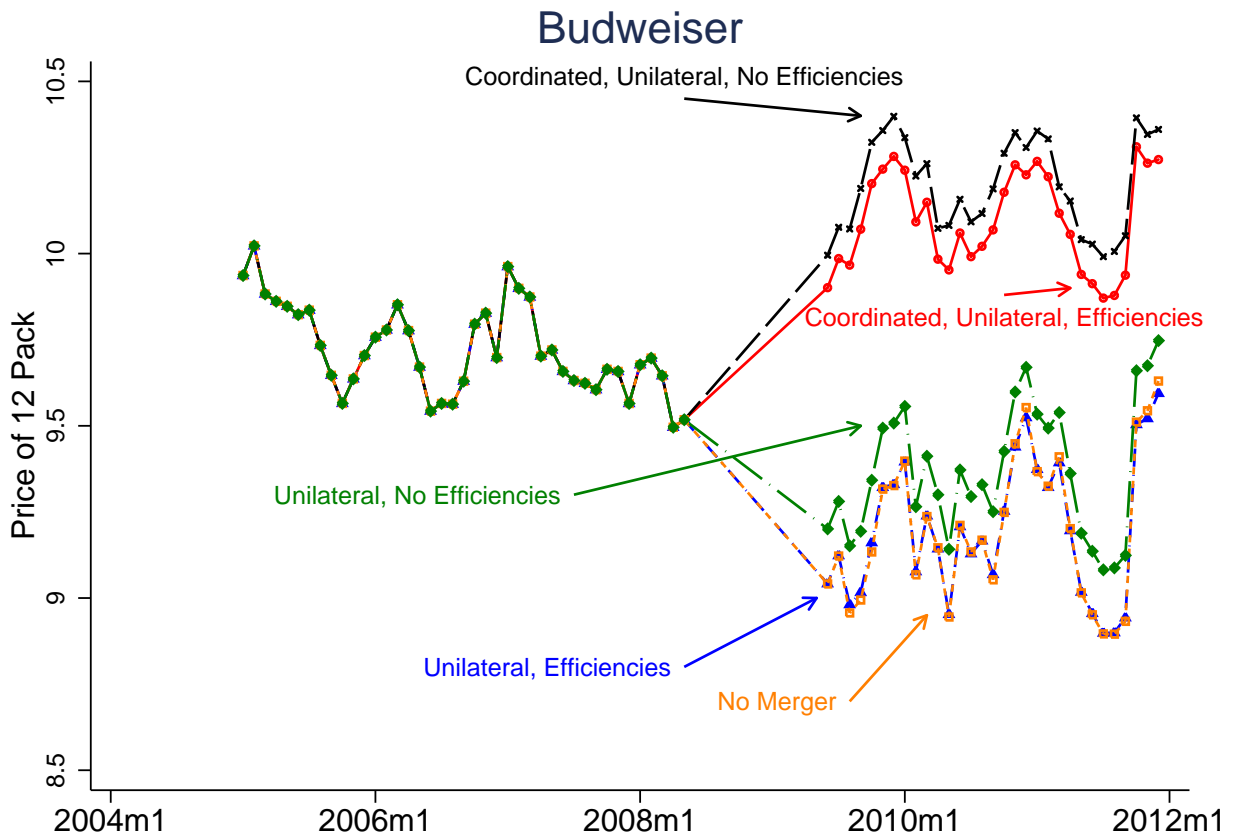


Figure C.3: Counterfactual Price Series for Budweiser Light

Notes: The figure plots the average retail prices of Budweiser 12-packs. The red prices labeled “Coordinated, Unilateral, Efficiencies” are the raw data. The gold prices labeled “No Merger” are numerically computed for a counterfactual in which the Miller/Coors merger does not occur. The blue prices labeled “Unilateral, Efficiencies” are the scenario in which the Miller/Coors merger occurs with unilateral effects and efficiencies but no coordinated effects. The green prices labeled “Unilateral, No Efficiencies” are the scenario in which the merger occurs with unilateral effects but without efficiencies or coordinated effects. The black prices labeled “Coordinated, Unilateral, No Efficiencies” are computed assuming the merger occurs with coordinated and unilateral effects but without efficiencies. Straight averages are calculated over the 39 regions in the data.

Table C.1: Median Own-Price and Cross-Price Demand Elasticities

	Bud Light	Budweiser	Coors	Coors Light	Corona Extra	Corona Light	Heineken	Heineken Light	Miller G. D.	Miller High Life	Miller Lite
Bud Light	-4.06	0.177	0.017	0.187	0.043	0.018	0.029	0.007	0.037	0.068	0.199
Budweiser	0.366	-4.268	0.017	0.187	0.043	0.018	0.029	0.007	0.037	0.068	0.199
Coors	0.366	0.177	-4.455	0.187	0.043	0.018	0.029	0.007	0.0373	0.068	0.199
Coors Light	0.366	0.177	0.017	-4.261	0.043	0.018	0.029	0.007	0.037	0.068	0.199
Corona Extra	0.056	0.027	0.003	0.028	-6.114	0.059	0.091	0.023	0.006	0.010	0.030
Corona Light	0.056	0.027	0.003	0.028	0.138	-6.271	0.091	0.023	0.006	0.010	0.030
Heineken	0.056	0.027	0.003	0.028	0.138	0.059	-6.248	0.023	0.006	0.010	0.030
Heineken Light	0.054	0.025	0.002	0.028	0.132	0.059	0.086	-6.323	0.005	0.010	0.029
Miller G.D.	0.366	0.177	0.017	0.187	0.043	0.018	0.029	0.007	-4.447	0.068	0.199
Miller H.L.	0.366	0.177	0.017	0.187	0.043	0.018	0.029	0.007	0.037	-3.372	0.199
Miller Lite	0.366	0.177	0.017	0.187	0.043	0.018	0.029	0.007	0.037	0.068	-4.245

Notes: The cell entry in row i and column j is the percentage change in the quantity of product i due to a one percent increase in the price of product j . All products tabulated here are 12-packs. Elasticities are calculated as the median over the region-period combinations.

Table C.2: Median Diversion Ratios

	Bud Light	Budweiser	Coors Light	Coors Light	Coors Extra	Coors Light	Corona Light	Corona Light	Heineken Light	Heineken Light	Heineken Light	Miller G. D.	Miller High Life	Miller Lite
Bud Light	-	0.044	0.004	0.045	0.008	0.003	0.003	0.005	0.001	0.001	0.009	0.021	0.049	
Budweiser	0.085	-	0.004	0.043	0.007	0.003	0.003	0.005	0.001	0.001	0.009	0.020	0.047	
Coors	0.081	0.040	-	0.041	0.007	0.003	0.003	0.005	0.001	0.001	0.008	0.019	0.045	
Coors Light	0.085	0.041	0.004	-	0.007	0.003	0.003	0.005	0.001	0.001	0.009	0.020	0.047	
Corona Extra	0.013	0.006	0.001	0.006	-	0.010	0.010	0.015	0.004	0.004	0.001	0.003	0.007	
Corona Light	0.012	0.006	0.001	0.006	0.022	-	0.015	0.015	0.004	0.004	0.001	0.003	0.007	
Heineken	0.012	0.006	0.001	0.006	0.022	0.010	0.010	-	0.004	0.004	0.001	0.003	0.007	
Heineken Light	0.012	0.006	0.001	0.006	0.022	0.010	0.010	0.014	-	0.001	0.001	0.003	0.007	
Miller G.D.	0.082	0.040	0.004	0.041	0.007	0.003	0.003	0.005	0.001	0.001	-	0.019	0.045	
Miller H.L.	0.083	0.040	0.004	0.042	0.007	0.003	0.003	0.005	0.001	0.001	0.008	-	0.046	
Miller Lite	0.085	0.041	0.004	0.043	0.007	0.003	0.003	0.005	0.001	0.001	0.009	0.020	-	

Notes: The cell entry in row i and column j is given by the median of $\left| \frac{\partial s_i / \partial p_j}{\partial s_j / \partial p_j} \right|$ over the region-period combinations. All products tabulated here are 12-packs.

Table C.3: Price-Cost Relationships Pre-Merger and Post-Merger

	Miller Lite		Coors Light		Bud Light		Budweiser	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Constant	7.09 (0.08)	8.20 (0.06)	4.20 (0.27)	8.07 (0.38)	6.67 (0.40)	7.89 (0.28)	6.68 (0.41)	7.83 (0.35)
Marginal Cost	0.45 (0.08)	0.42 (0.06)	0.87 (0.28)	0.44 (0.07)	0.58 (0.07)	0.46 (0.05)	0.58 (0.07)	0.47 (0.06)
R^2	0.435	0.619	0.800	0.571	0.490	0.466	0.978	0.965
# Observations	1548	1157	1599	1117	1597	1174	1597	1174

Notes: The table shows the results of univariate OLS regressions. The dependent variable is the retail price and the regressor is the marginal cost imputed from the structural model. Observations are 12-packs at the region-year-month level. Results are reported separately for the pre-merger period (i.e., before June 2008) and the post-merger periods (i.e., after May 2009), and separately for the Miller Lite, Coors Light, Bud Light, and Budweiser Brands. Standard errors are clustered at the region level and reported in parentheses.

Table C.4: Welfare Effects of Miller/Coors Merger in Millions of Dollars

	(i)	(ii)	(iii)	(iv)	(v)
<i>Scenario Description</i>					
Coordinated Effects	yes	yes	no	no	no
Unilateral Effects	yes	yes	yes	yes	no
Efficiencies	yes	no	yes	no	no
<i>Merger Effect on Producer Surplus</i>					
ABI	4.73	7.81	0.29	3.13	.
Miller	7.04	4.55	3.81	1.71	.
Coors	5.33	2.03	3.27	0.47	.
Total Industry	17.42	14.83	7.40	5.46	.
<i>Merger Effect on Consumer Surplus</i>					
Total Industry	-14.12	-18.45	-1.26	-6.32	.
<i>Merger Effect on Total Surplus</i>					
Total Industry	3.30	-3.61	6.14	-0.86	.

Notes: The table provides the effect of the Miller/Coors merger on producer surplus, consumer surplus, and total surplus. All numbers are millions of dollars, relative to the “No Merger” scenario in which the Miller/Coors merger does not occur, and are for the year 2011. Column (i) considers the scenario in which the merger occurs with coordinated effects, unilateral effects, and efficiencies. This best reflects the raw data. Column (ii) considers the counterfactual scenario in which the merger occurs with coordinated and unilateral effects but without efficiencies. Column (iii) considers the counterfactual scenario in which the merger occurs with unilateral effects and efficiencies but no coordinated effects. Column (iv) considers the counterfactual scenario in which the merger occurs with unilateral effects but without efficiencies or coordinated effects. No numbers are shown for column (v), which represents the baseline scenario in which no merger occurs.