Who Pays for Retail Electric Deregulation?:
Evidence of Cross-Subsidization from Complete Bill Data[†]

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Abstract: Retail electric deregulation, known as customer choice, has been identified in the literature to have favorable price impacts to businesses and households because of the introduction of a competition construct into the rate-setting mechanism. Those studies often ignore the important role of regulatory intervention. They are also generally national or multi-state aggregated studies that ignore state- and utility-specific dynamics, and nearly all rely on Electricity Information Administration (EIA) price data that does not account for additional costs of riders and surcharges on consumer bills, which total more than 60 percent of total bills in states like Ohio. Using a unique panel of complete final electricity bill data from the Public Utilities Commission of Ohio (PUCO), this paper provides a multi-utility panel regression analysis of the effect of retail deregulation on actual electric bills in Ohio. The results identify two main sources of cross-subsidization that have more than negated any favorable effects of retail deregulation. Both cross-subsidies result in substantial cost shifts to residential consumers.

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1. Introduction

Energy policy research has been dominated by a focus on efficiency rather than equity. The answer to the question "do retail customers benefit?" has long eluded researchers studying the emergence, implementation, and impact of electricity market deregulation, often referred to as restructuring. Lawmakers and other original proponents of reform argued that improved resource allocation as a result of restructuring would trickle down to customers, resulting in reduced electric rates to both businesses and households (Winston, 1993). Today, empirical support for these claims remains frustratingly opaque (Eto et al., 2006; Joskow, 2008; Kwoka, 2008; Swadley & Yucel, 2011). As Bushnell, Mansur, and Novan (2017) note in a recent literature review, "arguably, the most fundamental question regarding restructuring relates to its impact on consumers' electricity prices. Here, again, the empirical research is somewhat muddled" (p. 11). In this paper, we provide an empirical analysis of the impact of retail electric restructuring using a unique final bill dataset from Ohio. We evaluate the impact of restructuring on residential, commercial and industrial customers, with an explicit focus on cross-subsidization. We begin with a concise summary of the empirical literature on retail restructuring and cross-subsidization.

1.1 Prior Empirical Research

Empirical work on the effect of retail restructuring is inconclusive at best. Apt (2005) found no net impact in a study of price effects for industrial customers. In contrast, Joskow (2006) identified residential and industrial savings associated with retail competition. It has been argued that these and other earlier studies include a variety of empirical and theoretical limitations, including inadequate or imperfect accounting of confounding market and regulatory changes (Kwoka, 2008). Subsequent studies have improved explanatory power and granularity. Swadley and Yücel (2011), using choice participation rates as a measure of retail market competitiveness, determined that retail prices decreased following retail restructuring. Using Electricity

Information Administration (EIA) retail price data and a dynamic panel model of 16 restructured U.S. states and DC, they found that competition reduced retail price mark-ups relative to wholesale price, indicating improved efficiency. Su (2015), who assessed the impact of retail choice availability on EIA's retail price data using a national panel from 1990 to 2011, found no impact on commercial and industrial customer prices and only short-term price reductions for residential customers. Su attributed these results to rate freezes and lower natural gas fuel costs.[1]

Ros (2017), who assessed the impact of retail competition on average revenue per unit sales using a 72-utility panel from 1972 to 2009, found that retail competition results in lower prices for all customer classes, but that the impact varies.[2] More specifically, Ros finds residential, commercial, and industrial price impacts of -4.3%, -8.2%, and -11.1%, respectively. His results indicate that over time these benefits deteriorate, remain static, and increase for residential, commercial, and industrial customers, respectively. Hartley, Medlock, and Jankovska (2017) employ final bill data from Texas and find a benefit to residential customers from retail choice as compared to non-restructured parts of the state. They attribute this savings to declining service provider costs, reduced price mark-ups, and the increased pass-through of wholesale market costs. Like several other studies, theirs links retail rates to the cost of the marginal fuel source, in this case natural gas.

One critical component of the original efficiency argument was that restructuring would diminish any inter-class cross-subsidization, resulting in aggregate benefits to all customer classes, by replacing regulation with transparent and impartial open-markets. While scale economies, principally benefiting the commercial and industrial classes, would be unaffected by restructuring, it was argued that reforms would "reduce the magnitude of the subsidies and

[1] Su does find that full retail choice (i.e., choice available to all customer classes) does benefit industrial customers, but attributes this result to spillovers from protections put in place for residential customers.
[2] In his study, average revenue per unit sales is a proxy for price, as derived from FERC Form 1 Data.

gradually eliminate those that do not have broad public support" (Joskow, 1998, p. 45). But as with retail price, empirical confirmation of the elimination of cross-subsidies is equally unclear. Nagayama (2007) evaluated industrial to residential electric price ratios relative to GDP per capita and maturity of electric market reform in an 83-nation longitudinal study. The findings indicated that market reforms have inconsistent impacts depending upon the type of economy and maturity of markets, with the general result suggesting that industrial prices fell most after reform in developing countries. Erdogdu (2011) expands on Nagayama's work by incorporating developed countries and additional fuel-cost controls into a 63-nation panel of price-cost margin and cross-subsidy ratios from 1982 to 2009. Again, the results suggested that most market reforms appear to have inconsistent, country-specific effects. The study also finds, however, that the introduction of retail choice increases cross-subsidy in developed countries.[3] Erdogdu interprets this as decreased efficiency.

Besides empirical assessments, several scholars attribute changes in cross-subsidization to market reform. Su (2015) theorizes that cross-subsidization from residential to industrial customers dissipated after the introduction of retail competition, partially explaining residential cost decreases. Hartley, Medlock, and Jankovska (2017) argue that the elimination of cross-subsidization from commercial to residential customers partially explains decreases in commercial and industrial costs after retail restructuring. Of crucial importance is the explanation for the functional mechanism by which restructuring would affect inequalities in the relative cost of electricity as measured by the inter-class price ratio. This is unfortunately absent or incomplete in all of the available literature.

[3] The exact direction of the effect is unclear due to the use of the absolute value of deviation in price ratio as the dependent variable. Nonetheless, separate models indicate falling residential price-cost margin and insignificant change in industrial customer price-cost margin due to retail choice. This implies that the cross-subsidy increases in favor of residential customers. These results are consistent with theory found in Nagayama's work (2007).

1.2 Improved Metrics

A critical shortcoming of prior research is its reliance on EIA 826 data. It provides an incomplete assessment of actual bills that residential, industrial, and commercial customers receive, as it is based on a simplified ratio of reported distribution utility revenue to customer count or sales volume. It misses important aspects of complex holding company structures. Revenues obtained via customer bills but routed to corporate subsidiaries, arms-length divested generation companies (gencos), or parent corporations do not show up in that data. In many cases, EIA data miss indirect costs and other flow-through revenues that all customers see in the form of non-bypassable riders and surcharges, which can amount to over 60 percent of the total bill.[4] With the exception of Hartley, Medlock, and Jankovska (2017), all previous empirical research on electric restructuring in the U.S. has relied on this bill proxy data rather than final bill data.

Relatedly, empirical work in the US has consistently relied on aggregate multi-state panel data as the basis of their assessments for market restructuring, and have neglected key state- and utility-level regulatory policy interventions. These details can be crucial. This has produced non-trivial identification error. For example, recent multi-state longitudinal studies such as Su (2015) and Ros (2017) use EIA's Status of Electricity Restructuring reports to code the year of restructuring. This report is based upon enabling legislation rather than the functional mechanism that is being measured (i.e., when customer switching actually began). Ros's panel data codes Ohio restructuring as beginning in 2001, and his panel ends in 2009. But in Ohio, as discussed below, the actual tariff mechanism that permitted customer switching coincided with the passage of Senate Bill 221 in 2008. As a result, no real switching occurred during the last nine years of his panel, representing the entirety of his policy intervention for the State of Ohio. This begs the

[4] Non-bypassable riders are revenues collected by the distribution utility that appear on all customer bills regardless of whether the customer has "switched" to obtaining supply from a marketer or not. The interested reader is encouraged to see 155 FERC ¶ 61,101, and 155 FERC ¶ 61,102 (April 27, 2016).

question of what these prior studies are actually measuring, as it is likely that they are conflating secondary market effects with restructuring effects.

The Public Utilities Commission of Ohio (PUCO) publishes detailed final bill data on a monthly basis for all customer classes separately. Using this data, this paper provides a more fine-grained panel analysis of seven metro areas in the State of Ohio corresponding to utility service areas, accounting for important subtleties omitted from prior research (e.g., actual switching implementation, divestiture). This paper provides utility-level assessments of the impact of retail restructuring, and incorporates greater detail than prior studies by incorporating explanatory variables for zonal load-weighted wholesale price, actual final delivery price of fuel inputs as opposed to futures data, and utility operational costs inclusive of labor, capital, amortization, and depreciation. This paper draws conclusions about cross-subsidization and consumer welfare in the context of retail restructuring and market design. Our findings have broad implications for welfare and political economy issues inherent to deregulation that should inform other states and nations, as well as methodological and data-use considerations for future research.

Before introducing the empirical analysis, the next section of this paper provides a general background on electricity deregulation, with a concise summary of Ohio’s experience with restructuring. It then provides important conceptual details for cross-subsidization and divestiture that are necessary for understanding the research design and empirical aspects of the paper.

2. Theoretical Foundation

2.1 Electric Market Reform

Electric restructuring consists of a variety of market reforms intended to improve economic efficiency. The canonical model of reform in developed countries includes unbundling competitive market segments such as generation, introducing new or expanded wholesale markets, establishing rules and independent oversight that supports open transmission access, and initiating either competitive generation procurement or retail choice (Chao & Huntington, 1998; Joskow & Schmalensee, 1983; Joskow, 1989; 1998; 2006; Hunt, 2002). The intended outcomes for retail rate determination and cost allocation are, in theory, nearly identical to the principles of "cost of service" regulation for vertical monopolies: rates should be transparent, encourage investment, avoid cross-subsidies, and foster efficient decision-making by customers and utilities alike (Phillips, 1993).[5] A longstanding and well-respected literature has justified a healthy skepticism that these goals can be achieved under traditional regulatory designs (Averch & Johnson, 1962; Stigler & Friedland, 1962; Posner, 1974; Peltzman, 1976; many others). The claims of proponents of restructuring thus highlighted these well-established shortcomings of regulatory systems, arguing that market-based reforms would improve efficiency to all customers. Both scholars and practitioners also argued that these reforms would reduce the scope and magnitude of cross-subsidies, which are commonplace in electric rates.[6]

2.2 Retail Restructuring

Retail restructuring is an important subcomponent of overall electricity market reform because it establishes the mechanism by which the benefits of competitive reforms to wholesale markets are realized by retail customers. After restructuring, distribution utilities, which remain regulated, were expected to competitively procure generation through contracts or auctions, or, alternatively, give way to more-direct retail customer access to wholesale markets via wheeling arrangements or retail suppliers (e.g., brokers or marketers) (Joskow, 1998). Several scholars have voiced skepticism about the cost-effectiveness of retail choice as compared to other

[5] Perhaps the biggest theoretic difference is a shift from an average cost to a marginal cost basis of rate determination (Woo & Zarnikau, 2009; Borenstein & Bushnell, 2015).

[6] For example, electric rates are often used to support rural customers, small businesses, and low-income customers, provide economic incentives to attract new industry, prop-up local fuel sources (especially coal), and promulgate environmental policy, among other political, social, and economic interventions (Joskow, 1998).

competitive procurement strategies (Joskow & Schmalensee, 1983; Joskow, 2000; Defeuilley, 2009). Nevertheless, a significant plurality of states and countries that undertook electric restructuring also adopted consumer choice in some capacity.[7] The literature articulates several potential benefits of consumer choice. For example, it can stimulate new products (e.g., aggregation) and services (e.g., green portfolios) as well as create liquidity in wholesale markets (Littlechild, 2000; 2002). Ohio adopted both forms of retail restructuring: open retail markets and customer choice. Utilities in Ohio adopted the use of Competitive Bidding Price (CBP) auctions to procure default, standard service offer (SSO) supply.[8] Both supply mechanisms procure generation from the same competitive wholesale markets. Consequently, in a competitive market, CBP and retail choice offer prices should converge to the same average costs for generation, excepting for differences in competitive business practices.[9]

2.3 Restructuring in Ohio

Ohio, like many of its peers in the U.S. and other developed countries, followed a winding and imperfect path to implementing electric market deregulation.[10] The seeds of restructuring were sown by declining marginal costs for wholesale power in the 1990s as compared to the higher average cost prices paid by retail customers. Industrial and commercial customers, in response, lobbied for market reforms and greater wholesale market access. The state initiated restructuring in 1999 with the passage of Senate Bill (SB) 3, which started a five-year "market development" period during which retail rates remained frozen and utilities were allowed to recover stranded costs through transition charges. The PUCO subsequently delayed retail markets via "Rate Stabilization Plans" (RSPs) until, in 2008, Ohio passed SB 221.

[7] For instance, according to the EIA, 20 U.S. states have adopted some form of liberalized retail choice. The extent of availability differs (e.g., limitations to certain customer classes or participation caps) (EIA-861, 2016).
[8] Retail choice allows customers to elect to receive energy services from an alternative, certified retail electric supplier (CRES). The SSO is the default option for customers that do not chose an alternative supplier.
[9] For example, prices may diverge from cost in response to product and service offerings, hedging strategies, and other contract terms (e.g., duration, termination fees, etc.). In Ohio today, retail choice offers are generally slightly higher than SSO offers.
[10] See the works of Littlechild (2008), Thomas, Lendel, and Park (2014), and Dormady, Jiang, and Hoyt (2017) for a more thorough overview of Ohio's deregulation process.

SB 221 officially ended traditional cost-of-service ratemaking for generation and established market-based retail ratemaking, including retail choice markets. Under the CBP auction design, wholesale providers bid to supply tranches of the distribution utility's SSO obligation, putting pressure on the supply-component of SSO rates to align with wholesale prices. Like virtually all states and countries that have restructured to-date, Ohio did not follow the strict guidance of early theorists (Joskow & Schmalensee, 1983; Hunt, 2002; Joskow, 2008) in two important ways. First, Ohio did not require functional separation of generation from the distribution utilities, instead allowing "corporate" separation in which the distribution utilities could maintain ownership of their generation fleets in arms-length subsidiaries (Dormady, 2017). Second, Ohio retained regulatory intervention in the form of "Electric Security Plans" (ESPs).[11] ESPs reduced the procedural requirements of utilities for gaining approval for additional cost recovery, allowing what practitioners call "single issue ratemaking." Essentially, SB221 made it easier for utilities to obtain non-bypassable riders and surcharges on bills. As a consequence, Ohio's experience reflects other "real-world" restructuring efforts and mirrors the experience of other states (e.g., New York, Illinois, Pennsylvania).

2.4 Type I and II Cross-Subsidization

Given the regulatory environment in Ohio and many similarly-situated countries and U.S. states, there are two main types of cross-subsidization that customers see. Each of these can be identified independently of one another using our econometric approach. For ease of exposition, we designate these as Type I and II cross-subsidization.

A Type I cross-subsidy identifies cross-subsidization between customer class (i.e., residential, industrial, and commercial) and occurs on the consumption/demand side. In

[11] ESPs allow utilities to pursue non-bypassable riders, tariffs, and other price interventions during the SSO determination process. Ohio also established a competitive "Market Rate Offer" (MRO) mechanism for setting SSO rates but did not obligate its use.

deregulated markets like Ohio, a single retail price has been set by a CBP auction for all customer classes. The only marginal rate differences between classes are due to regulatory-approved riders and surcharges on customer bills (i.e., the regulated portion of customer bills that studies relying on EIA data would not entirely pick-up). Regulators may approve Type I cross-subsidies for economic development purposes or for alternative political rationales.[12] Evidence of Type I cross-subsidization would be observed when the relative marginal cost of retail electric prices between any two customer classes changes.

A Type II cross-subsidy identifies cross-subsidization between consumers and utility-affiliated generation units. This type occurs on the production side. Distribution utilities in states like Ohio tend to be heavily invested in legacy coal generation. Because the four main distribution utilities in Ohio were only required to corporately separate, rather than functionally divest, their generation units under the state's restructuring plan (see Dormady, Jiang and Hoyt, 2017), their distribution companies' parent corporations generally retained ownership of the units through a holding company structure as a subsidiary corporation (see Dormady, 2017). For example, AEP created AEP Generation Services Corporation and FirstEnergy created FirstEnergy Generation, LLC to retain ownership of their legacy coal units. Type II cross-subsidies would likely be observed when there is a profit differential between utility-affiliated generation and independent competitive wholesale generation.[13] In the presence of a Type II cross-subsidy, customers would be offsetting distribution utility losses through increased retail prices.

[12] For example, Amazon Inc. has data centers in the Columbus area in AEP's service territory representing over $1 Billion in investment. A recent proposal before PUCO, if approved, would exempt those data centers from at least twelve riders, representing substantial savings to Amazon (Gearino, 2017).

[13] For example, recent declines in the price of natural gas have made utility-affiliated coal units less profitable in wholesale markets. We would thus expect to observe Type II cross-subsidization in service territories of distribution utilities that have not functionally divested legacy coal units.

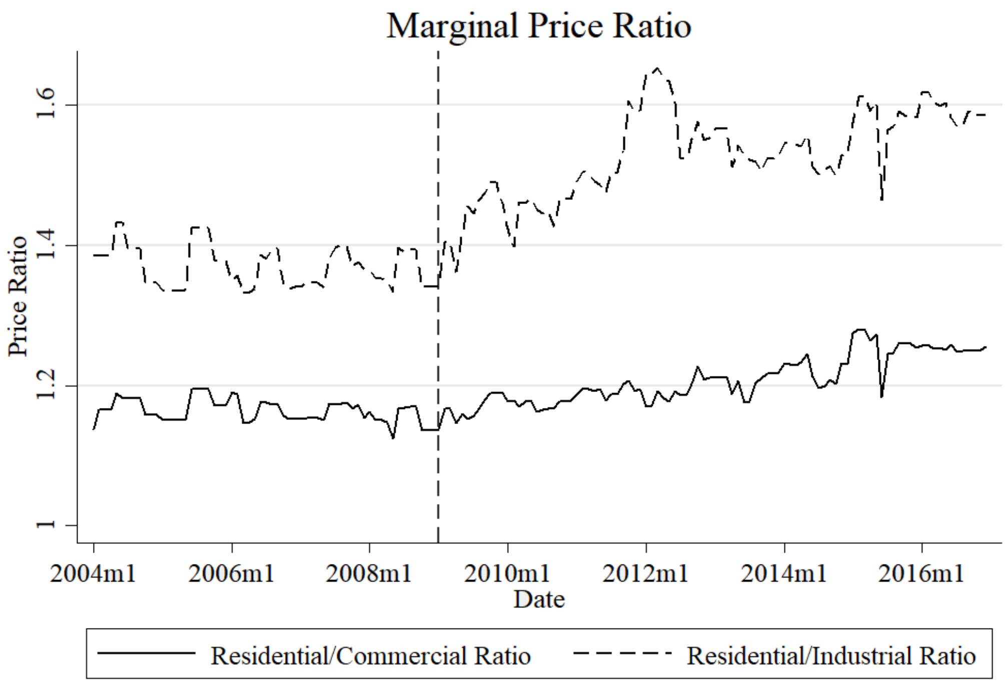
3. Data

We develop a monthly panel dataset representative of the seven main metropolitan areas in Ohio for the period January 2004 through December 2016.[14] We adopt two sets of dependent variables: 1) the marginal price of Standard Service Offer electricity in cents per kilowatt hour for residential, commercial, and industrial customers; and 2) the marginal price ratios of residential to industrial price, and residential to commercial price. Electricity price data is provided by the PUCO monthly Ohio Utility Rate Survey. Unlike EIA data, PUCO data provides total electric bills, inclusive of generation, T&D, and all other regulatory approved costs such as riders and surcharges. There are a variety of advantages to using total consumer bills (Dormady, Jiang, & Hoyt, 2017; Hartley, Medlock, & Jankovska, 2017). Notably, total bill data encompasses both direct and indirect costs borne by consumers. EIA marginal prices, on the other hand, are estimates derived by dividing revenues reported by the distribution utility (i.e., the numerator) by total consumption of electricity by all customers of the distribution utility, including customers who switched to a competitive supplier (i.e., the denominator). The revenue component of the numerator includes only distribution company revenues, excluding revenues obtained on customer bills that flow through to parent companies, arms-length subsidiaries, and corporately separated gencos. Thus, EIA's price estimates deflate the numerator. And, by including customers who have switched to competitive suppliers for their generation charge in the denominator, they inflate the denominator.

Unlike final bill data, EIA data does not allow for complete assessments of cross-subsidization. The PUCO reports total bills based on fixed average consumption levels for each customer class (750 kWh for residential, 300,000 kWh for commercial, and 6 million kWh for

[14] These seven utilities are the FirstEnergy affiliates Toledo Edison (Toledo), Ohio Edison (Akron), and the Cleveland Electric Illuminating Company (CEI) (Cleveland); the AEP affiliates Columbus Southern Power (CSP) (Columbus) and Ohio Power (Canton) (merged effective January 1, 2012); Duke Energy (Cincinnati) (formerly Cinergy Corporation until the acquisition completion date of April 3, 2006); and, Dayton Power & Light (DP&L) (Dayton).

industrial). We provide a time series plot of the panel-average inter-class marginal price ratio in Figure 1 for the period both before and after retail deregulation. Individual panels are provided in the Appendix.



Vertical line indicates implementation of retail electric deregulation beginning January 2009

Figure 1. Statewide Average Marginal Price Ratio Pre- and Post-Restructuring

We focus on four primary explanatory variables: the price of natural gas and coal delivered to utilities in Ohio in mmBTUs; the wholesale, load-weighted locational marginal price (LMP) of electricity; and a retail restructuring dummy variable. Use of the final delivery price of both gas and coal input fuels captures transportation costs not picked up in other studies that rely on futures data. [15] Input fuel pricing data is provided in Figure 2. We note the historic declines in the price of gas that coincide with the U.S. shale production boom beginning in 2008. Hourly wholesale pricing data for PJM and MISO, the applicable regional energy markets, is obtained

[15] This would include non-trivial costs collected by rail transport such as Berkshire Hathaway's BNSF Railway Co.

from MarketViews and, for historical MISO load data, from MISO archives.[16] For consistency across all years of our panel, we do not use PJM's updated residual metered load aggregate technique adopted in June 2015. We convert hourly LMP, inclusive of congestion and losses, to monthly load-weighted average LMP for each utility. Wholesale price captures the value of energy sold, i.e., the prevailing market rate. It also reflects diurnal cycles and variability related to weather, forced or unforced generation outages, as well as other changes in market conditions happening outside of Ohio. Wholesale data is provided in Figure 3 for each utility.

Table 1. Data Definitions, Units and Source

Variable Name	Description	Unit	Source
Price_Residential	Monthly indicative residential marginal price by metro area based on complete bill and usage fixed at 750 kWh	₵/kWh	PUCO
Price_Commercial	Monthly indicative commercial marginal price by metro area based on complete bill and usage fixed at 300,000 kWh	₵/kWh	PUCO
Price_Industrial	Monthly indicative industrial marginal price by metro area based on complete bill and usage fixed at 6,000,000 kWh	₵/kWh	PUCO
NatGasDeliv_Price	Monthly wholesale fuel price for natural gas inclusive of delivery cost	$/mmBTU	EIA, EPM, Table 4.10.A
CoalDeliv_Price	Monthly wholesale fuel price for coal inclusive of delivery cost	$/mmBTU	EIA, EPM, Table 4.10.A
LMP	Hourly PJM and MISO LMPs weighted by hourly load and aggregated into monthly rates	$/MWh	PJM, MISO
Div_Com_Stock	Dollar amount of dividends issued to common stock holders	Billions USD	FERC Form 1/ 3-Q
Div_Pref_Stock	Dollar amount of dividends issued to preferred stock holders	Billions USD	FERC Form 1/ 3-Q
Tot_Op_Expn	Dollar amount of operations expenses for the reporting electric entity, inclusive of capital, labor, O&M, amortization & depreciation	Billions USD	FERC Form 1/ 3-Q
Res_Sales_Mwh	Megawatt-hours provided to residential customers by the reporting electric entity	Millions MWh	FERC Form 1/ 3-Q
Comm_Sales_Mwh	Megawatt-hours provided to small commercial firms by the reporting electric entity	Millions MWh	FERC Form 1/ 3-Q
Ind_Sales_Mwh	Megawatt-hours provided to large commercial firms by the reporting electric entity	Millions MWh	FERC Form 1/ 3-Q

Acronyms: mmBTU: one million British Thermal Units; EIA: Energy Information Administration; EPM: Electric Power Monthly; FERC: Federal Energy Regulatory Commission; kWh: Kilowatt-hour; LMP: Locational Marginal Price; MISO: Midcontinent Independent System Operator; MWh: Megawatt-hour; PJM: PJM Interconnection; PUCO: Public Utility Commission of Ohio. *Note*: Form 1 and 3-Q correspond to the FERC annual and quarterly report of major electric utilities.

[16] See https://www.misoenergy.org/Library/MarketReports/Pages/ArchivedHistoricalRegionalForecastandActualLoad.aspx

Table 2. Summary Statistics

Variable Name	Mean	Std. Dev.	Min	Max
Price_Residential	13.0492	1.6368	8.7707	18.5557
Price_Commercial	11.1239	1.9933	6.1407	16.9645
Price_Industrial	9.2160	2.2724	5.4294	16.2932
NatGasDeliv_Price	6.5781	3.8801	1.5035	17.7917
CoalDeliv_Price	2.1312	0.2799	1.5495	2.7359
LMP	44.0637	13.5698	23.9861	102.9773
Div_Com_Stock	0.1307	0.0189	0.0000	0.1345
Div_Pref_Stock	0.0004	0.0043	0.0000	0.0714
Tot_Op_Expn	0.1735	0.1545	0.0300	1.2806
Res_Sales_Mwh	0.5696	0.2584	0.1480	1.4972
Comm_Sales_Mwh	0.4663	0.2373	0.0429	1.3712
Ind_Sales_Mwh	0.5691	0.2990	0.0052	1.2957

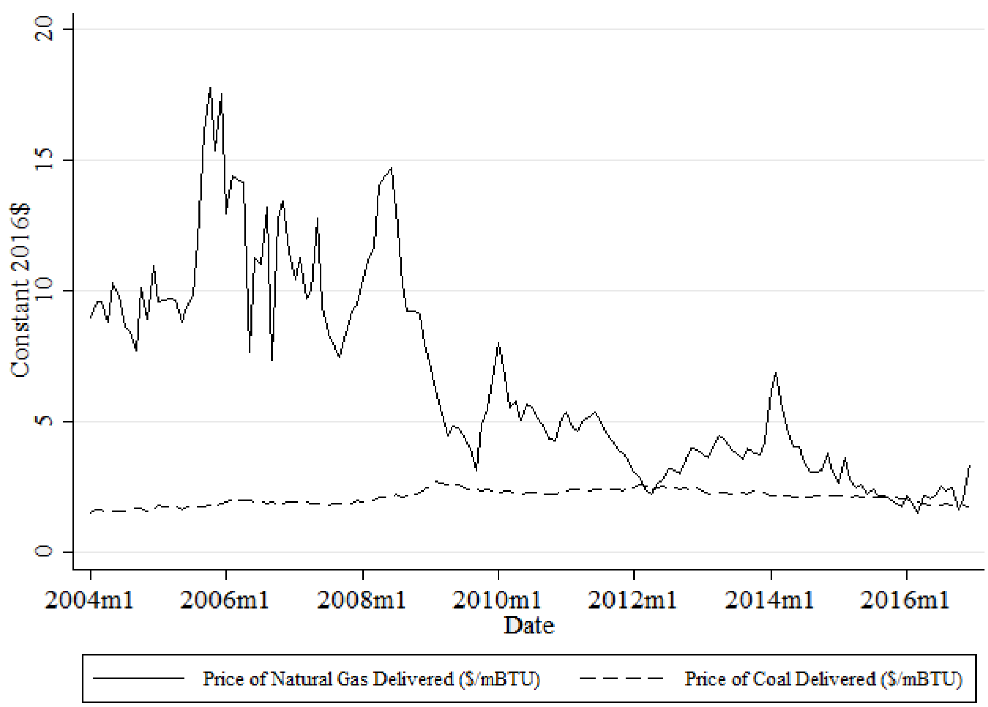


Figure 2. Price of Natural Gas and Coal

Note: Figure provides the monthly inflation-corrected final marginal price of natural gas and coal ($/mmBTU) delivered to distribution utilities in Ohio between 2004 and 2016. *Source*: EIA EPM Table 4.10A, 2017.

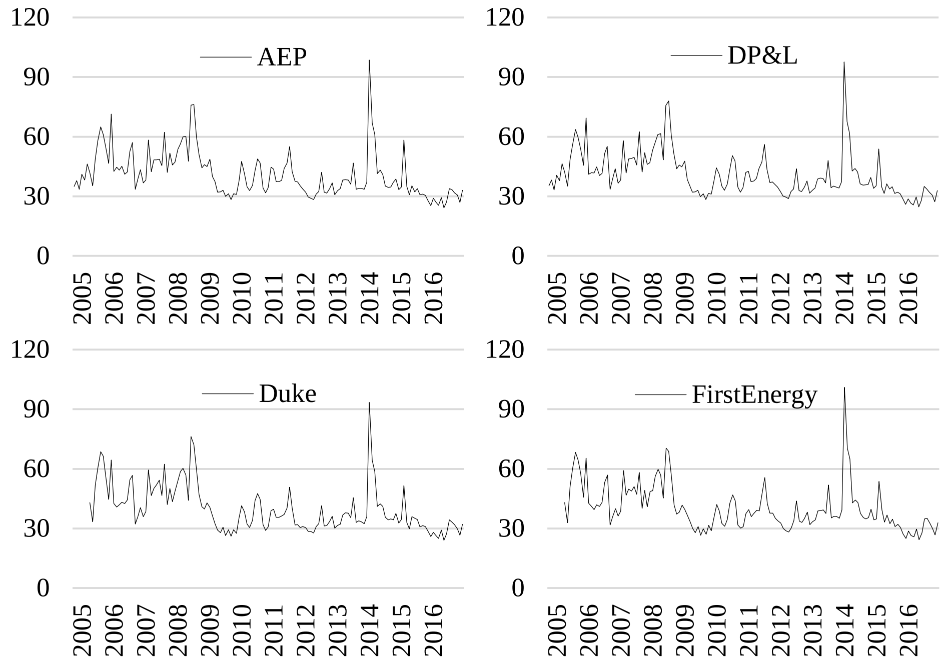


Figure 3: Wholesale Electric Price by Utility Pricing Zone ($/MWh)
Note: Figure provides inflation-corrected monthly load-weighted locational marginal prices (LMPs) for each of the four electric distribution utilities operating in Ohio. *Source*: PJM, MISO, MarketViews.

We also use key control variables. We obtain total utility operations and maintenance cost data from FERC Form 1 (comprehensive annual report) and Form 3 (quarterly report). The total operations costs data consists of electricity-related capital expenditures inclusive of amortization and depreciation, maintenance, labor, regulatory and tax expenditures, and operations. We were careful to ensure that our database queries did not obtain these values for other services of the utility (e.g., gas). Also obtained from Form 1 and 3 data are dividends declared common and preferred stock, and total sales in MW by customer class. The latter provides an important control for aggregate consumption.

4. Econometric Approach

We utilize an econometric estimation approach that is well-suited to our data; long-panels for seven metro areas. We develop estimation models for each customer class (residential, commercial, and industrial) as well as price ratio models that allow us to assess inter-class differential price effects. Each of the price models estimates marginal retail electric price in inflation-corrected cents/kWh. We also utilize the same estimation approach for our price ratio dependent variables, which consists of the inter-class marginal price ratio.

Model selection began with a battery of statistical tests. Following Wooldridge (2010) and Cameron and Trivedi (2005), we utilized a more robust version of the Hausman test under the likely case of a random effects estimator that is not fully efficient and in consideration that heteroscedasticity, autocorrelation, or temporal and cross-sectional dependency are typical problems embedded in microeconometric data such as long panels (Hoechle, 2007). The tests strongly suggested that a fixed effects estimation model would provide more consistent estimates. Nonetheless, this version of the Hausman test still considers that neither cross sectional dependence of the errors across units nor within units exists in the data. In order to test for the validity of these assumptions, we performed the Pesaran cross-sectional dependence test. The result implied the presence of cross-sectional dependence of residuals across units (Pesaran, 2004). We also tested for the presence of heteroscedasticity and serial correlation within units, which is common in long panels. Both tests indicated that residuals are not only heteroscedastic but also autocorrelated within units. In this case, it is important to estimate standard errors that allow for the modeling of cross sectional dependence, heteroscedasticity, and autocorrelation. Finally, we also performed several tests for unit roots and found that the panels are stationary.

Given the statistical test findings, we adopted a model that is more consistent with our data, which is a fixed effects regression model that incorporates Driscoll and Kraay (1998) standard errors. The advantage of using a Driscoll-Kraay estimator is that it allows for the application of a Newey-West type correction (Newey and West, 1987), accounting for a general form of autocorrelation in the residuals. This adjustment is also incorporated into the sequence of cross-sectional averages of the moment conditions, which ensures a consistent estimator of the covariance matrix regardless of the quantity of panels (Hoechle, 2007). The general functional form of our estimation models is given by:

$$p_{it,\tau} = \mathbf{d}_{i,\tau}\delta + \mathbf{z}_{t,\tau}^{gas}\gamma_{gas} + \mathbf{d}_{i,\tau}\mathbf{z}_{t,\tau}^{gas}\zeta_{gas} + \mathbf{z}_{t,\tau}^{coal}\gamma_{coal} + \mathbf{W}_{it,\tau}\omega + \mathbf{C}_{it,\tau}\varphi + \mathbf{X}_{it,\tau}\chi + \mathbf{T}_{\tau}\alpha + v_i + \varepsilon_{it,\tau} \quad (1)$$

$$p_{it,\tau} = \mathbf{d}_{i,\tau}\delta + \mathbf{z}_{t,\tau}^{lmp}\gamma_{lmp} + \mathbf{d}_{i,\tau}\mathbf{z}_{t,\tau}^{lmp}\zeta_{lmp} + \mathbf{W}_{it,\tau}\omega + \mathbf{C}_{it,\tau}\varphi + \mathbf{X}_{it,\tau}\chi + \mathbf{T}_{\tau}\alpha + v_i + \varepsilon_{it,\tau} \quad (2)$$

where $p_{it,\tau}$ is the marginal price per kWh in metro area i at month t of year τ. Our main explanatory variables are $\mathbf{d}_{i,\tau}$ and $\mathbf{Z}_{t,\tau}$. $\mathbf{d}_{i,\tau}$ is a binary variable that indicates retail restructuring at month t in year τ. It takes the value of 1 beginning January of 2009.[17] The second set of variables, $\mathbf{Z}_{t,\tau}$ represent the final marginal price of delivered input-fuels. Thus, $\mathbf{Z}_{t,\tau}$ is a vector of input fuel prices for coal and gas, as well as monthly load-weighted wholesale LMP for each distribution utility's pricing zone within their relevant RTO market. Although we have broadly defined the **Z** matrix containing input-fuel marginal prices, we have only included gas and coal prices in the general form of model 1 (i.e., $\mathbf{z}^{\text{gas}}$ and $\mathbf{z}^{\text{coal}}$), on the one hand, and LMP in the general form of model 2 (i.e., $\mathbf{z}^{\text{lmp}}$).

We also incorporate vectors associated with additional production side features. $\mathbf{W}_{it,\tau}$ is a vector representing distributional factors for each distribution utility that consists of dividends converted to common and preferred stock. This also includes total operations costs, capital, and labor costs as discussed above, and is given by vector $\mathbf{C}_{it,\tau}$. $\mathbf{X}_{it,\tau}$ is a vector representing electricity sales, in MWh, for a distribution utility and provides a control for monthly demand side effects (e.g., weather, consumption patterns, regional growth).[18] All models incorporate year fixed

[17] The exception is for Dayton which is served by DP&L. In this case, the dummy takes the value of 1 starting in January 2011.

[18] It is common practice in econometric applications to treat equilibrium prices and quantities as endogenously determined and utilize a simultaneous-equation system for estimation. However, as Ros, (2017, p.78) notes, "when prices are regulated, as is the case in the electricity sector, the relationship between prices and quantities in a simultaneous-equations system may be weaker than in regulated markets and thus perhaps there is less of a need for treating prices and quantities as endogenous." In our case, this is underscored further by the fact that we utilize complete bill data that incorporates the entirety of regulated costs, and by the

effects that help to address annual changes in productivity and autonomous energy efficiency improvements (AEEI). These are given by $\mathbf{T}_\tau$, in which each binary variable takes the value of 1 for year τ (from 2004 to 2016) and 0 otherwise.

As previously mentioned, our models use the Driscoll-Kraay estimator for the computation of standard errors, which are obtained as the square roots of the diagonal elements of the robust covariance matrix. These have the following form:

$$V(\hat{\theta}) = (\mathbf{M}'\mathbf{M})^{-1}\hat{S}_T(\mathbf{M}'\mathbf{M})^{-1} \ , \qquad (3)$$

where **M** is a vector of independent variables and $\hat{S}_T$ is an estimation of S_T, the asymptotic covariance matrix. [19] In this case, $\hat{S}_T$ is defined as provided by Newey and West (1987).

In addition to models 1 and 2, we also run price ratio models where $p_{it,\tau}^{residential,k}$ represents the ratio of residential prices to comparison class *k* (either industrial or commercial).

$$p_{it,\tau}^{res,k} = \mathbf{d}_{i,\tau}\delta + \mathbf{z}_{t,\tau}^{gas}\gamma_{gas} + \mathbf{d}_{i,\tau}\mathbf{z}_{t,\tau}^{gas}\zeta_{gas} + \mathbf{z}_{t,\tau}^{coal}\gamma_{coal} + \mathbf{W}_{it,\tau}\omega + \mathbf{C}_{it,\tau}\varphi + \mathbf{X}_{it,\tau}\chi + \mathbf{T}_\tau\alpha + v_i + \varepsilon_{it,\tau} \qquad (4)$$

$$p_{it,\tau}^{res,k} = \mathbf{d}_{i,\tau}\delta + \mathbf{z}_{t,\tau}^{lmp}\gamma_{lmp} + \mathbf{d}_{i,\tau}\mathbf{z}_{t,\tau}^{lmp}\zeta_{lmp} + \mathbf{W}_{it,\tau}\omega + \mathbf{C}_{it,\tau}\varphi + \mathbf{X}_{it,\tau}\chi + \mathbf{T}_\tau\alpha + v_i + \varepsilon_{it,\tau} \qquad (5)$$

These take a value equal to 1 when the marginal price ratio between classes is equal. It takes a value greater than 1 when residential customers observe a higher marginal rate, and less than one when residential customers observe a lower marginal rate.

5. Results

5.1 Overall Effects

Before introducing the econometric results, we begin with a basic test of Type I cross-subsidization (i.e., inter-class). We conduct non-parametric tests of the null hypothesis that the

fact that the marginal price component is based upon fixed average consumption levels by customer class. Consequently, in this case, the correlation between aggregate consumption and the marginal price of customers' final bills is quite low.

[19] Readers who are interested in a more detailed explanation should refer to Newey and West (1987), Driscoll and Kraay (1998), and Hoechle (2007).

inter-class marginal price ratio is unaffected by retail restructuring. Beginning with this basic test provides a higher-level assessment of this type of cross-subsidization in the absence of additional considerations or statistical controls. The results of these tests are provided in Table 3.

Under textbook deregulation including retail restructuring, we would expect one of two effects on the ratio of prices between customer class: 1) no change, as would be the case if Ohio retained the existing allocation of costs; or 2) decreases in the price ratios reflecting price convergence due to the introduction of market-based, competitive ratemaking via CBP auctions. The results of the hypotheses tests however do not support either expectation. Almost consistently in each metro area, price ratios increased reflecting a greater disparity between residential marginal price and industrial and commercial marginal price, respectively. In most cases the null is rejected at the 0.01 level. Deviations from this trend are observed in Columbus where we see a statistically-significant increase in the price ratio for residential to commercial price, only. Similarly, in Cleveland we observe a statistically significant increase in the residential to industrial price ratio only. We also observe slight decreases in both ratios in the Dayton metro area. The largest change is observed in Canton, where we observe an 8-point decrease in the residential to commercial ratio; though we observe a 9-point increase in the residential to industrial ratio there.

The hypothesis test results generally run counter to expectations of proponents, indicating increases in Type I. To more fully understand these results, we next turn to our econometric models that allow us to control for key explanatory features like input fuel prices, wholesale market price, operations and maintenance costs, amortization and capital depreciation, etc., in further isolating the effects of both Type I and II cross-subsidization.

Table 3. Pre- and Post-Retail Choice Marginal Price Ratios

Metro Area	Residential/Industrial Ratio			Residential/Commercial Ratio		
	Pre-Retail Choice	*Retail Choice*	*Δ*	*Pre-Retail Choice*	*Retail Choice*	*Δ*
Akron	1.34	1.45	0.11***	1.06	1.19	0.13***
Canton	1.50	1.59	0.09**	1.36	1.28	-0.08***
Cincinnati	1.37	1.46	0.09***	1.18	1.21	0.03**
Cleveland	1.10	1.35	0.25***	1.06	1.06	0.00
Columbus	1.87	1.88	0.01	1.16	1.23	0.07***
Dayton	1.51	1.48	-0.03***	1.36	1.35	-0.01***
Toledo	0.91	1.46	0.55***	0.96	1.12	0.16***

Note: Values indicate the ratio of residential price to the reference class (e.g., 1.5 indicates the marginal price charged to residential customers is 150% of the industrial or commercial reference group). The delta column reports the difference between pre- and post-retail choice marginal price ratios. Asterisks indicate the significance level of Mann-Whitney non-parametric hypothesis tests of the mean equality between the two policy periods by metro area. *** p<0.01, ** p<0.05, * p<0.1

5.2 Regression Results

The results of our regression analyses are presented in Tables 4 through 8. As identified above, we provide five sets of models with two main outcome measures: 1) final retail bill marginal price (in constant US cents/kWh), and 2) retail electric bill marginal price ratio. The outcome variable in the models provided in Tables 4 through 6 is the final monthly electric bill for residential, commercial and industrial customers. The outcome variable in the models provided in Tables 7 and 8 is the marginal price ratio for residential to industrial and residential to commercial, respectively.

Each table provides four regression models. Models 1 and 2 use input fuel prices of natural gas and coal delivered to utilities as explanatory variables. Models 3 and 4 use the load-weighted LMP. Models 2 and 4 provide interactive models that decompose our policy intervention (retail restructuring) variable by distribution utility company. Models 2 and 4 decompose gas price and wholesale price by utility, respectively. Both models include their respective input price variables (either fuel or wholesale price) interacted with our policy intervention dummy variable for post-retail deregulation. All models provide year fixed effects with the earliest year in our panel, 2004, excluded as the reference case.

5.2.1 Type I (Inter-class) Cross-Subsidization

Evaluating the ratio models in comparison to the price models allows us to estimate both Type I and II cross-subsidization. We begin by first evaluating Type I. The results of the ratio models indicate that the state's retail deregulation has generally had minimal overall effect on the disparity in electric rates between residential customers and industrial customers. We observe very slight and statistically significant decreases in the overall statewide effect on the residential to commercial ratio between -.036 and -.062. This is driven predominantly by reductions in the residential to commercial ratio in the DP&L service territory of between -.08 and -.09. The lack of statistical significance in the residential to industrial ratio is driven by disparate results in the DP&L service territory and the FirstEnergy territory. We observe a statistically significant increase in this ratio for FirstEnergy in Model 4 of .22, but we observe a statistically significant decrease in this ratio for DP&L in both Models 2 and 4 of between -.26 and -.27. Thus, the lack of an aggregate impact on the largest relative price disparity, the residential to industrial ratio, is driven by countervailing effects of retail deregulation in two relevant service territories. We next turn to evaluations of the price regressions to understand these effects further.

In all cases and for all customer classes, we observe a positive coefficient associated with the aggregate statewide impacts of retail deregulation in Models 1 and 3. This indicates that the overall statewide effect of retail deregulation has been an increase in electric rates for all customer classes. However, we observe statistically significant increases in these models only for residential (of between 1.02 and 1.16 cents/kWh) and commercial (of between 1.2 and 1.7 cents/kWh) customers. For industrial customers we do not observe a statistically significant increase. While further decomposition by utility, which we turn to next, is needed to understand this further, the overall results provide some evidence of Type I cross-subsidization. That is, the only customer class to not observe significant rate increases associated with retail deregulation is the industrial class.

Decomposing these effects by utility as provided in Models 2 and 4, we observe statistically significant decreases in residential rates by 2.24 cents/kWh in the FirstEnergy territory, and 2.3 cents/kWh in the Duke territory. We do not observe a statistically significant effect for residential customers in the DP&L territory. And in the AEP service territory, we observe a statistically significant increase of between 1.95 and 3.77 cents/kWh. Thus, the overall residential effect has been mitigated by the significant increase in residential rates in the AEP service territory. Relatedly, we fail to observe statistically significant commercial customer savings in all models with the exception of Model 2 for FirstEnergy, in which we observe a 1.83 cent/kWh savings. However, we observe a commercial increase of between 2.79 and 4.27 cents/kWh in the AEP territory.

Comparing those results with the industrial results is most indicative of Type I cross-subsidization. We observe statistically significant industrial rate decreases in the FirstEnergy territory of between 2.79 and 3.59 cents/kWh. And, we observe decreases of between 2.39 and 2.47 cents/kWh in the Duke territory. However, we observe industrial price increases in the AEP territory of between 2.32 and 3.12 cents/kWh. Comparing these industrial price effects with the residential and commercial price effects within each utility territory indicates that where prices decreased with retail deregulation, the greatest savings were allocated to industrial customers. And, these results indicate that where prices increased with retail deregulation, they increased least for industrial customers. In other words, industrial customers observe greater gains to the gainers, but fewer losses to the losers.

It is instructive that the effect of retail deregulation has resulted in disparate effects across customer class. This is because the mechanism for setting the generation component of customer bills (i.e., the deregulated component of bills) is the CBP auction, which results in a single price for all three customer classes. Moving to a system in which this component is the same for all three customer classes should, all things equal, tend to harmonize prices across customer classes and thus bring them more in line with one another or have no net effect. It is important to note that with a single price component for generation, the only mechanism that would permit differential price effects is the regulated component of electric bills (i.e., riders and surcharges). Thus, regardless of whether savings or costs ensue as a result of retail restructuring, inter-class differences in those cost or savings are driven by the regulated component of retail rates. Next, we turn to the supply side.

5.2.2 Type II (Production Side) Cross-subsidization

We next evaluate production side cross-subsidization, Type II. With the precipitous decline in natural gas price associated with the natural gas boom and hydraulic fracturing, the state has observed significant declines in both the price of natural gas as delivered to electric generators as well as the load-weighted wholesale LMP.[20] It has similarly observed a substantial buildup of the natural gas fleet (Dormady, 2017).[21] This has placed utility-affiliated gencos in a precarious position as they are almost entirely coal-fired.

The regression results provide strong evidence that the favorable decrease in natural gas prices has tended to have an upward (unfavorable) effect on retail electric prices, with one

[20] The most common production resource to set the LMP, particularly in the PJM RTO, is natural gas. Thus, gas tends to be the marginal resource in the dispatch merit order that most commonly sets the auction-clearing price in the day-ahead and real-time markets.

[21] Ohio has observed a monotonically-increasing natural gas generation fleet, predominantly from non-utility-affiliated wholesale generation. Between 2004 and 2016, the first and last years of the panel utilized for this analysis, the gas component of the fuel fleet has increased from 0.01 percent to 31.7 percent. There is currently approximately 3,000 MW of planned construction in Ohio by the year 2020 (see EIA's Electric Power Monthly Table 6.5, available at http://www.eia.gov/electricity/monthly/). According to PJM, 6,740 MW of capacity was deactivated in Ohio in 2015 and several additional unit retirement requests are pending currently (see http://www.pjm.com/planning/generation-deactivation/gd-summaries.aspx). These are predominantly coal-fired units. Numerically, Ohio is likely to observe a gas fleet on par with its coal fleet within the next few years.

notable and important exception discussed below. Both Models 1 and 2 provide regression results of input fuel prices for coal and gas as delivered to Ohio utilities. Model 1 provides the aggregate statewide marginal effect of gas price, and its interaction with the deregulation policy dummy provides the aggregate post-deregulation marginal effect. Model 2 provides each of these decomposed by utility. We note that the expected sign of the input fuel price coefficients is positive. Thus, a negative coefficient associated with gas price indicates that decreases in gas price results in increases in retail rates. The change from an overall marginal effect of -.04 to a post-deregulation marginal effect of -.24 as identified in residential price model is indicative of significant increases in Type II cross-subsidization associated with retail deregulation.

The monthly average price of natural gas delivered to electric generation units in Ohio has decreased from between $12 and $15 dollars per mmBTU before retail deregulation, to approximately $2.20 today. Thus, interpreting these coefficients indicates that an approximately ten-dollar decrease in the price of gas has had an overall effect of increasing residential electric rates by approximately .5 cents/kWh, but that effect after retail deregulation is 2.42 cents/kWh. That exceeds a 450 percent increase in Type II cross-subsidization on residential bills. In a deregulated market that has moved toward a more market-based pricing construct for pricing retail power, historic decreases in the price of a key input fuel, like natural gas, should translate in some way to savings to retail customers. Ohio customers have observed the opposite effect, however. Historic decreases in gas price have resulted in losses to arms-length utility-affiliated coal generation. The data indicates that those losses have been cross-subsidized by the regulated component of retail electric bills. We also observe similar effects for commercial rates; although the overall effect falls just shy of standard levels of statistical significance (t=1.92), the post-deregulation effect is highly statistically significant.

It is noteworthy that, in terms of magnitude, the deleterious effects of Type II cross-subsidization tend to more than cancel out any favorable effects of retail deregulation. For example, in the retail price regression models, the net effect of retail deregulation has been a savings to households of at most 2.2 to 2.3 cents/kWh. But we observe an average of 2.4 cents/kWh increase in residential rates associated with the Type II cross-subsidy. In other words, where retail deregulation has benefitted customers on the deregulated component of their bills, those effects have been more than cancelled out by corresponding increases in the regulated component of their bills.

Evaluating the results of Model 2 allows us to decompose these effects by utility. Where we observe statistically significant effects, we observe a negative gas price coefficient that corresponds with Type II effects. Again, this excludes one notable and important exception that we will discuss below. For customers located in the FirstEnergy territory, as well as AEP and DP&L territories, where we observe significant coefficients we generally observe an inverse relationship between gas price and electric rates for all customer classes.

Also noteworthy are the significant magnitude differentials for this effect between customer classes in the AEP service territory. For residential and commercial customers, there is a statistically significant post-deregulation effect that is larger in magnitude than that observed by industrial customers. For industrial customers, a ten dollar decrease in the gas price is associated with a 4.75 cent/kWh increase in rates. But for residential and commercial customers, that same effect results in a 6.2 to 6.4 cent/kWh increase. This suggests that Type II cross-subsidization can contribute to Type I effects. This would suggest that for AEP, the PUCO has approved correspondingly larger riders for households and commercial customers than for industrial customers.

Table 4. Regression Analysis of Retail Price (Residential Bills)

	(1)	(2)	(3)	(4)
RESIDENTIAL MARGINAL PRICE	XTSCC	XTSCC-I	XTSCC	XTSCC-I
Deregulation	1.159		1.020*	
	(0.601)		(0.430)	
Deregulation_FirstEnergy		-2.241**		-0.00195
		(0.694)		(0.680)
Deregulation_AEP		3.774***		1.946**
		(0.806)		(0.664)
Deregulation_Duke		-2.303*		-1.836
		(0.986)		(1.054)
Deregulation_DP&L		-0.559		0.0251
		(0.968)		(0.783)
NatGasDeliv_Price	-0.0467*			
	(0.0201)			
GasPrice_FirstEnergy		-0.0794*		
		(0.0349)		
GasPrice_AEP		-0.0239		
		(0.0368)		
GasPrice_Duke		-0.0303		
		(0.0516)		
GasPrice_DP&L		-0.0512***		
		(0.0118)		
Deregulation_GasPrice	-0.242**			
	(0.0879)			
Deregulation_GasPrice_FirstEnergy		-0.138		
		(0.0865)		
Deregulation_GasPrice_AEP		-0.637***		
		(0.126)		
Deregulation_GasPrice_Duke		0.342*		
		(0.166)		
Deregulation_GasPrice_DP&L		0.339		
		(0.203)		
CoalDeliv_Price	0.0135	0.517		
	(0.596)	(0.469)		
LMP			-0.00120	
			(0.00527)	
LMP_FirstEnergy				0.0218**
				(0.00778)
LMP_AEP				-0.00142
				(0.00712)
LMP_Duke				-0.0266
				(0.0151)
LMP_DP&L				-0.0111*
				(0.00549)
Deregulation_LMP			-0.0270**	
			(0.00737)	
Deregulation_LMP_FirstEnergy				-0.0522***
				(0.0108)
Deregulation_LMP_AEP				-0.0344**
				(0.0130)
Deregulation_LMP_Duke				0.00978
				(0.0216)
Deregulation_LMP_DP&L				0.0139
				(0.0149)

Div_Com_Stock (billions)	10.81***	2.237	10.72**	3.371
	(2.894)	(2.060)	(3.165)	(2.325)
Div_Pref_Stock (billions)	-8.031*	3.241	6.862	8.525*
	(3.821)	(3.700)	(3.802)	(3.874)
Tot_Op_Expn (billions)	-0.625	-1.777***	0.216	-0.789
	(0.571)	(0.402)	(0.998)	(0.644)
Res_Sales_Mwh (millions)	4.393***	2.512***	4.125***	3.340***
	(0.588)	(0.517)	(0.607)	(0.524)
Comm_Sales_Mwh (millions)	-0.734	-0.842	-0.469	-0.128
	(0.790)	(0.469)	(0.766)	(0.533)
Ind_Sales_Mwh (millions)	-1.772***	-1.864***	-1.922***	-1.817***
	(0.376)	(0.288)	(0.393)	(0.332)
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	11.65***	12.38***	9.904***	10.96***
	(1.151)	(0.861)	(0.330)	(0.276)
N	1,092	1,092	1,005	1,005
R-squared	0.432	0.709	0.466	0.663
F	45.88	124.6	65.30	305.8

Models report fixed effects panel regression estimates with Driscoll-Kraay standard errors using the *xtscc* subroutine in Stata 14. All models include year fixed effects. Standard errors are provided in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The notable exception to all of this that we have been alluding to is Duke Energy, the distribution utility in the Cincinnati metro area. We note that Duke Energy is the only distribution utility in Ohio that has functionally divested, rather than corporately separated, nearly all of its generation assets.[22] Duke Energy does not maintain a large legacy coal fleet and thus has no need to cross-subsidize losses of a legacy coal fleet with proportionate increases in retail electric bills. Other distribution utilities in the state have only corporately separated their legacy coal fleets. For them, losses of utility-affiliated generation show up on the distribution utility's parent company's balance sheets. That forces them to experience a confounded cost recovery incentive that results in this inverse relationship that appears so robustly in the econometric models. Since the completion of their divestiture in 2014, Duke has not had this same incentive.

[22] Duke, along with seven other utilities in both regulated and deregulated markets, does continue to own an entitlement to a small share of a cooperative known as the Ohio Valley Electric Corporation (OVEC). OVEC maintains and operates two legacy coal plants which, historically, provided service to a Department of Energy (DOE) managed uranium enrichment plant. DOE's agreement with OVEC will end by 2023, and most power requirements already ended in 2003. An inter-company power agreement between the sponsoring utilities, however, will run through 2040. As a result, Duke is responsible for nine percent of OVEC's power market costs and benefits, equivalent to ownership of approximately 215 MW of coal generation. Prior to divestiture, this amounted to less than four percent of Duke's Ohio generation business. Duke, to-date, has had minimal involvement in discussions regarding OVEC subsidization. This will likely change if other utilities successfully receive economic support for their share of OVEC.

Table 5. Regression Analysis of Retail Price (Industrial Bills)

INDUSTRIAL MARGINAL PRICE	(1) XTSCC	(2) XTSCC-I	(3) XTSCC	(4) XTSCC-I
Deregulation	1.205		0.944	
	(0.650)		(0.570)	
Deregulation_FirstEnergy		-3.596***		-2.799***
		(0.732)		(0.683)
Deregulation_AEP		3.119***		2.324***
		(0.687)		(0.532)
Deregulation_Duke		-2.468**		-2.392*
		(1.001)		(1.112)
Deregulation_DP&L		0.906		1.659*
		(0.869)		(0.778)
NatGasDeliv_Price	(0.650)			
	-0.0205			
GasPrice_FirstEnergy		-0.0225		
		(0.0254)		
GasPrice_AEP		-0.0171		
		(0.0299)		
GasPrice_Duke		-0.0789		
		(0.0572)		
GasPrice_DP&L		0.00565		
		(0.0353)		
Deregulation_GasPrice	-0.172			
	(0.0969)			
Deregulation_GasPrice_FirstEnergy		-0.0784		
		(0.123)		
Deregulation_GasPrice_AEP		-0.475***		
		(0.0927)		
Deregulation_GasPrice_Duke		0.457**		
		(0.149)		
Deregulation_GasPrice_DP&L		0.145		
		(0.172)		
CoalDeliv_Price	0.353	0.915**		
	(0.552)	(0.340)		
LMP			-0.00989	
			(0.00696)	
LMP_FirstEnergy				0.00133
				(0.00569)
LMP_AEP				0.00294
				(0.00582)
LMP_Duke				-0.0421**
				(0.0161)
LMP_DP&L				0.000367
				(0.00849)
Deregulation_LMP			-0.0119	
			(0.00875)	
Deregulation_LMP_FirstEnergy				-0.0202*
				(0.0100)
Deregulation_LMP_AEP				-0.0334**
				(0.00974)
Deregulation_LMP_Duke				0.0435*
				(0.0220)
Deregulation_LMP_DP&L				-0.00508
				(0.0130)
Div_Com_Stock (billions)	7.299*	-4.543	9.226**	-1.382
	(3.304)	(2.643)	(3.480)	(2.414)

Div_Pref_Stock (billions)	-1.637	14.32	16.92***	18.58*
	(7.071)	(8.187)	(4.200)	(8.519)
Tot_Op_Expn (billions)	-0.604	-0.796	0.170	-0.0257
	(0.634)	(0.414)	(1.195)	(0.676)
Res_Sales_Mwh (millions)	3.976***	1.647***	3.610***	2.370***
	(0.512)	(0.384)	(0.551)	(0.449)
Comm_Sales_Mwh (millions)	-1.716**	-1.209**	-1.525*	-0.795*
	(0.661)	(0.335)	(0.639)	(0.351)
Ind_Sales_Mwh (millions)	-1.916***	-1.945***	-1.900***	-1.799***
	(0.407)	(0.241)	(0.403)	(0.258)
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	8.946***	9.295***	7.805***	9.420***
	(1.020)	(0.676)	(0.460)	(0.321)
N	1,092	1,092	1,005	1,005
R-squared	0.177	0.668	0.210	0.638
F	17.07	198.9	40.52	184.5

Models report fixed effects panel regression estimates with Driscoll-Kraay standard errors using the *xtscc* subroutine in Stata 14. All models include year fixed effects. Standard errors are provided in parentheses. *** p<0.01, ** p<0.05, * p<0.1

For Duke not only do our regression results indicate net savings associated with retail deregulation of approximately 2.3 to 2.5 cents/kWh, but we also observe the only positive and statistically significant post-deregulation coefficient for gas price. In other words, the effect of retail deregulation has resulted in all three classes of customers observing savings associated with decreases in the gas price. For Duke, a ten dollar decrease in the price of gas is associated with a 3.4 cent/kWh, 3.6 cent/kWh, and 4.6 cent/kWh savings for residential, commercial, and industrial customers, respectively. Thus, our results would tend to support the conclusion that retail deregulation, if accompanied by adequate divestiture, can mitigate the incentive to seek Type II cross-subsidization. It is also noteworthy that for Duke we still observe proportionately larger savings for industrial customers. This suggests that while adequate divestiture may improve Type II cross-subsidization, it does not necessarily improve Type I.

Table 6. Regression Analysis of Retail Price (Commercial Bills)

	(1)	(2)	(3)	(4)
COMMERCIAL MARGINAL PRICE	XTSCC	XTSCC-I	XTSCC	XTSCC-I
Deregulation	1.700**		1.214**	
	(0.584)		(0.446)	
Deregulation_FirstEnergy		-1.828**		-0.466
		(0.630)		(0.635)
Deregulation_AEP		4.273***		2.785***
		(0.658)		(0.610)
Deregulation_Duke		-1.304		-1.774
		(0.901)		(1.009)
Deregulation_DP&L		0.249		0.438
		(0.831)		(0.721)
NatGasDeliv_Price	-0.0417			
	(0.0217)			
GasPrice_FirstEnergy		-0.0585*		
		(0.0277)		
GasPrice_AEP		-0.0191		
		(0.0395)		
GasPrice_Duke		-0.0677		
		(0.0529)		
GasPrice_DP&L		-0.0434**		
		(0.0136)		
Deregulation_GasPrice	-0.267**			
	(0.0797)			
Deregulation_GasPrice_FirstEnergy		-0.172		
		(0.0938)		
Deregulation_GasPrice_AEP		-0.621***		
		(0.0938)		
Deregulation_GasPrice_Duke		0.359**		
		(0.143)		
Deregulation_GasPrice_DP&L		0.203		
		(0.163)		
CoalDeliv_Price	0.0785	0.589		
	(0.571)	(0.381)		
LMP			-0.00686	
			(0.00538)	
LMP_FirstEnergy				0.0101
				(0.00669)
LMP_AEP				0.00228
				(0.00793)
LMP_Duke				-0.0397**
				(0.0157)
LMP_DP&L				-0.0119*
				(0.00502)
Deregulation_LMP			-0.0209**	
			(0.00738)	
Deregulation_LMP_FirstEnergy				-0.0396**
				(0.0107)
Deregulation_LMP_AEP				-0.0372**
				(0.0128)
Deregulation_LMP_Duke				0.0395
				(0.0216)
Deregulation_LMP_DP&L				0.0103
				(0.0126)
Div_Com_Stock (billions)	11.12***	1.679	11.26**	3.114
	(2.860)	(1.709)	(3.158)	(1.910)

Div_Pref_Stock (billions)	2.294	15.99	19.45**	23.70*
	(8.673)	(10.02)	(7.037)	(10.80)
Tot_Op_Expn (billions)	-0.121	-0.271	0.636	0.600
	(0.589)	(0.441)	(1.074)	(0.674)
Res_Sales_Mwh (millions)	4.162***	1.936***	3.853***	2.665***
	(0.460)	(0.454)	(0.482)	(0.454)
Comm_Sales_Mwh (millions)	-0.791	-0.605	-0.584	-0.0326
	(0.692)	(0.377)	(0.656)	(0.421)
Ind_Sales_Mwh (millions)	-2.932***	-3.074***	-2.990***	-2.978***
	(0.399)	(0.323)	(0.406)	(0.341)
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	10.77***	11.32***	9.098***	10.25***
	(1.061)	(0.717)	(0.368)	(0.359)
N	1,092	1,092	1,005	1,005
R-squared	0.302	0.681	0.347	0.630
F	29.31	266.5	45.94	212.7

Models report fixed effects panel regression estimates with Driscoll-Kraay standard errors using the *xtscc* subroutine in Stata 14. All models include year fixed effects. Standard errors are provided in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Models 3 and 4 provide further insights. They replace the input fuel explanatory variables with the wholesale price of electricity. In the absence of Type II effects, we would expect decreases in the wholesale price to correspond with decreases in the retail price of electricity, particularly when the CBP auction that sets SSO rates closely tracks the wholesale price. However, in the presence of Type II effects, we expect an inverse relationship—decreases in the wholesale price correspond with reductions in generation revenue that incentivizes cross-subsidization by regulatory cost recovery.

Evaluating the results of Model 3 directly comports with Type II effects. We observe a statistically significant inverse relationship between the wholesale price and retail electricity prices after retail deregulation of -.027 for residential and -.021 for commercial. Again, in line with Type I effects, we do not observe statistically significant aggregate effects for industrial rates. Prior to retail deregulation the mean LMP was $55.3/MWh, and today it has fallen to approximately $29/MWh. This approximately $25 decrease in the wholesale price of electricity is associated with a .68 cent/kWh increase in residential retail rates and a .53 cent/kWh increase in commercial retail rates.

Table 7. Regression Analysis of Residential/Industrial Marginal Price Ratio

RESIDENTIAL/INDUSTRIAL MARGINAL PRICE RATIO	(1) XTSCC	(2) XTSCC-I	(3) XTSCC	(4) XTSCC-I
Deregulation	-0.0736		-0.0670	
	(0.0532)		(0.0504)	
Deregulation_FirstEnergy		0.143		0.223**
		(0.0911)		(0.0695)
Deregulation_AEP		-0.0234		-0.118
		(0.0720)		(0.0673)
Deregulation_Duke		0.130		0.183
		(0.0963)		(0.113)
Deregulation_DP&L		-0.255**		-0.272**
		(0.0690)		(0.0762)
NatGasDeliv_Price	-0.00128			
	(0.00205)			
GasPrice_FirstEnergy		-0.00499		
		(0.00317)		
GasPrice_AEP		0.000281		
		(0.00198)		
GasPrice_Duke		0.0120		
		(0.00659)		
GasPrice_DP&L		-0.00614		
		(0.00522)		
Deregulation_GasPrice	-0.00516			
	(0.00803)			
Deregulation_GasPrice_FirstEnergy		0.00326		
		(0.0141)		
Deregulation_GasPrice_AEP		-0.0175		
		(0.0121)		
Deregulation_GasPrice_Duke		-0.0347**		
		(0.0135)		
Deregulation_GasPrice_DP&L		0.0274**		
		(0.0109)		
CoalDeliv_Price	-0.0457	-0.0583		
	(0.0517)	(0.0492)		
LMP			0.00104*	
			(0.000521)	
LMP_FirstEnergy				0.00116
				(0.000674)
LMP_AEP				-0.000542
				(0.000290)
LMP_Duke				0.00436**
				(0.00169)
LMP_DP&L				-0.00131
				(0.00128)
Deregulation_LMP			-0.00118	
			(0.000705)	
Deregulation_LMP_FirstEnergy				-0.00115
				(0.00116)
Deregulation_LMP_AEP				-0.000610
				(0.00118)
Deregulation_LMP_Duke				-0.00617**
				(0.00205)
Deregulation_LMP_DP&L				0.00283*
				(0.00140)
Div_Com_Stock (billions)	-0.0605	0.622**	-0.244	0.438
	(0.262)	(0.231)	(0.274)	(0.228)

Div_Pref_Stock (billions)	-1.090*	-1.917**	-2.206***	-2.210***
	(0.479)	(0.580)	(0.363)	(0.541)
Tot_Op_Expn (billions)	-0.124*	-0.171**	-0.150	-0.192*
	(0.0616)	(0.0654)	(0.105)	(0.0878)
Res_Sales_Mwh (millions)	0.0446	0.102**	0.0592	0.126**
	(0.0554)	(0.0415)	(0.0567)	(0.0508)
Ind_Sales_Mwh (millions)	0.100**	0.0600	0.0994**	0.0670*
	(0.0391)	(0.0311)	(0.0387)	(0.0318)
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	1.424***	1.439***	1.408***	1.301***
	(0.0937)	(0.0906)	(0.0416)	(0.0341)
N	1,092	1,092	1,005	1,005
R-squared	0.362	0.558	0.371	0.558
F	60.55	84.90	60.71	71.68

Models report fixed effects panel regression estimates with Driscoll-Kraay standard errors using the *xtscc* subroutine in Stata 14. All models include year fixed effects. Standard errors are provided in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Again, decomposing these effects by utility as provided in Model 4, we observe Type II cross-subsidization effects. These coefficients are negative and statistically significant for AEP and FirstEnergy, indicating that customers have observed higher retail rates associated with decreases in the wholesale price. Additionally, we observe a statistically significant sign change for the residential effects for FirstEnergy. Before retail deregulation, decreases in the wholesale price would have been favorably passed on to consumers (as identified by the overall coefficient of .022). After retail deregulation these effects reversed and intensified (coefficient of -.052), indicating that a $25 decrease in the LMP is associated with a 1.3 cent/kWh increase in residential rates. This adverse Type II effect essentially cancels out any favorable effects associated with retail choice.

We also observe two statistically significant sign changes for the LMP coefficients for Duke. Whereas the overall LMP effects are -.039 and -.042 for commercial and industrial customers, they are .039 and .044 after retail restructuring. These indicate that before restructuring Duke ratepayers offset generation losses in the same manner as other Ohio utilities, but afterwards those effects reversed and customers began observing proportionate savings of the same magnitude as the losses they had incurred prior to divestiture.

Table 8. Regression Analysis of Residential/Commercial Marginal Price Ratio

RESIDENTIAL/COMMERCIAL MARGINAL PRICE RATIO	(1) XTSCC	(2) XTSCC-I	(3) XTSCC	(4) XTSCC-I
Deregulation	-0.0623**		-0.0366*	
	(0.0171)		(0.0152)	
Deregulation_FirstEnergy		-0.0155		0.0348
		(0.0367)		(0.0259)
Deregulation_AEP		-0.0614		-0.0573
		(0.0438)		(0.0396)
Deregulation_Duke		-0.0101		0.0533
		(0.0524)		(0.0562)
Deregulation_DP&L		-0.0983***		-0.0812***
		(0.0261)		(0.0192)
NatGasDeliv_Price	0.000418			
	(0.000848)			
GasPrice_FirstEnergy		-0.00143		
		(0.00142)		
GasPrice_AEP		0.000620		
		(0.00183)		
GasPrice_Duke		0.00531		
		(0.00323)		
GasPrice_DP&L		0.000389		
		(0.00166)		
Deregulation_GasPrice	0.00395			
	(0.00262)			
Deregulation_GasPrice_FirstEnergy		0.00816		
		(0.00565)		
Deregulation_GasPrice_AEP		-0.000565		
		(0.00767)		
Deregulation_GasPrice_Duke		-0.00992		
		(0.00677)		
Deregulation_GasPrice_DP&L		0.0114**		
		(0.00458)		
CoalDeliv_Price	-0.0115	-0.0186		
	(0.0206)	(0.0190)		
LMP			0.000577**	
			(0.000221)	
LMP_FirstEnergy				0.000704*
				(0.000319)
LMP_AEP				-0.0000475
				(0.000394)
LMP_Duke				0.00162
				(0.000870)
LMP_DP&L				0.000000724
				(0.000263)
Deregulation_LMP			-0.000260	
			(0.000282)	
Deregulation_LMP_FirstEnergy				0.0000621
				(0.000525)
Deregulation_LMP_AEP				-0.000327
				(0.000861)
Deregulation_LMP_Duke				-0.00293**
				(0.00104)
Deregulation_LMP_DP&L				0.000749*
				(0.000344)
Div_Com_Stock (billions)	-0.163	0.0438	-0.190	0.00580
	(0.166)	(0.133)	(0.174)	(0.134)

Div_Pref_Stock (billions)	0.162	-0.225	0.00147	-0.206
	(0.663)	(0.718)	(0.769)	(0.937)
Tot_Op_Expn (billions)	-0.0696**	-0.116**	-0.0658	-0.110**
	(0.0282)	(0.0346)	(0.0360)	(0.0392)
Res_Sales_Mwh (millions)	-0.0115	0.0302	-0.0106	0.0341
	(0.0365)	(0.0319)	(0.0365)	(0.0362)
Comm_Sales_Mwh (millions)	0.0951**	0.0611*	0.0967***	0.0654*
	(0.0257)	(0.0293)	(0.0260)	(0.0290)
Year Fixed Effects	Yes	Yes	Yes	Yes
Constant	1.167***	1.181***	1.153***	1.127***
	(0.0374)	(0.0344)	(0.0244)	(0.0288)
N	1,092	1,092	1,005	1,005
R-squared	0.257	0.354	0.266	0.354
F	40.01	58.87	45.13	47.90

Models report fixed effects panel regression estimates with Driscoll-Kraay standard errors using the *xtscc* subroutine in Stata 14. All models include year fixed effects. Standard errors are provided in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6. Implications & Conclusions

Prior assessments of retail electric restructuring are opaque with respect to inequalities in cost and ambivalent about its impact on consumers. As noted in the introduction, these studies generally rely upon EIA data that does not account for customer-funded pass-throughs associated with holding company structures. Prior U.S. research also generally adopts multi-state assessments that overlook important state- and utility-level dynamics, such as divestiture status, operational details, and other retail market dynamics. Few undertake an empirical analysis of relative changes in cross-subsidy. This paper provided a monthly panel analysis between 2004 and 2016 of the effect of Ohio's 2009 implementation of retail restructuring on residential, commercial, and industrial complete bills. The results provide robust evidence that retail restructuring led to increases in two types of cross-subsidization. While customers have generally observed some savings associated with the implementation of the competition construct, those savings have been more than offset by cross-subsidies to utility-affiliated gencos. Two robust measures of this effect, using the load-weighted wholesale LMP and the delivered price of natural gas, provide strong evidence that increases in customer bills following restructuring occurred in direct response to losses observed by utility-affiliated coal generation.

It is noteworthy that this effect occurred in almost exactly the opposite direction and magnitude for the only utility in the state that functionally divested essentially the entirety of its generation, Duke Energy. Customers in the Cincinnati metro area observed net savings associated with historic declines in the price of natural gas after retail deregulation. Decreases in natural gas price and associated declines in wholesale market prices are consistently associated with increasing electricity prices in all other service territories. This effect runs counter to both theoretical and empirical literature, which imply that retail rates should track wholesale rates and the fuel price of the marginal resource, typically natural gas, following retail restructuring.

As noted above, the classical model for electric deregulation includes unbundling of potentially competitive generation and retail services from regulated utility functions. Doing so removes the incentive for regulated utilities to preferentially exercise their monopoly power over network functions to support a deregulated affiliate. Absent protection against this behavior, scholars predicted de facto vertical-integration that would crowd out competition (Joskow & Schmalensee, 1983). Although most researchers agree that unbundling is essential, scholars differ about the level of separation necessary for a functioning retail market. The literature principally deals with two forms of unbundling: corporate separation, and full divestiture (Mansur, 2007; Bushnell, Mansur & Saravia, 2008; Kwoka, et. al., 2010; Ishii and Yan, 2010). Empirical evidence in support of either approach is limited.

In Ohio, regulated utilities operate under the corporate separation model and, except for Duke Energy, retain some affiliation with their legacy generation units. As Duke's customers have been the only customers in the state to observe savings corresponding to lower gas and wholesale prices, these results suggest that corporate separation is insufficient to remove important cross-subsidy incentives that otherwise manifest in consumer prices. These results are also suggestive both about Ohio's restructuring effort and the risks of imperfect retail restructuring in general. Ohio's retail restructuring law (SB 221) allowed mechanisms for utilities to seek additional cost-recovery in the form of non-bypassable riders and surcharges. Further compounding the issue, the ESP process in Ohio does not obligate the same procedural checks-and-balances as traditional cost-of-service regulation. In essence, Ohio created a competitive ratemaking mechanism but retained single-issue ratemaking. The empirical results from Ohio raise questions about the ability to effectively design competitive markets when political interests are involved. As Joskow (2008) and others note, incomplete or imperfect market reform is the status quo in most states and countries that adopted retail restructuring. The presence of residual regulatory interference appears to undermine the potential benefits of competition.

One prominent counterfactual explanation to the Type II subsidy results, is that increased costs are driven by growing requirements for T&D upgrades, including upgrades related to new metering technology, deferred upgrades from the transition period, and so forth. This explanation does not bare out in the evidence after controlling for operation costs, inclusive of O&M as well as amortized capital costs. Relatedly, our control for consumption shows the changes in prices are distinct from underlying growth trends.

The results also provide robust evidence of increases in inter-class cross-subsidization associated with retail restructuring. As just mentioned, the introduction of a competition construct has generally been associated with slight savings for Ohio customers with the exception of the AEP service territory. The results of this analysis suggest that, where customers observed savings, the greatest savings have been observed by industrial customers and, where customers have observed cost increases, the greatest increases have been observed by households. The overall net effect of retail restructuring in Ohio has not been favorable for households relative to large industrial customers.

Regarding inter-class cross-subsidization (Type I), we acknowledge that there may be important societal benefits, including economic development rationales, that would justify a residential to industrial ratio exceeding one. In other words, the exact ratio of cross-subsidization from households to job creators is a political and normative exercise rather than an empirical one. Here we simply report the results of our analyses that have provided robust evidence that these ratios changed in important ways with the implementation of retail restructuring. Given that Ohio's post-restructuring competition construct is a CBP auction that results in a single price to all three customer classes, these results run counter to expectations that a single price would tend to reduce inter-class differentials. They do, however, confirm Borenstein and Bushnell's (2015) argument that an underlying motivation for reform was always rent shifting. We note that we view our Type I results as a lower bound. Ohio is a highly industrialized state, home to many key manufacturers and energy-intensive corporations. Waivers from non-bypassable riders under consideration for Amazon and other key industrial corporations would not appear in our data. We anticipate that industrial and commercial customers would fare better relative to residential customers, more so than even our data currently suggests, after accounting for idiosyncratic waivers and exemptions.

We also note that Type I cross-subsidization is not generally an unexpected outcome of at-least partially regulated industries. Since Mancur Olson's (1965) seminal work on collective action, we have understood that oftentimes deliberative agency processes result in diffuse costs and concentrated benefits. Allowing differentials in cost across customer class to result from formalized rate-setting processes creates an incentive for rent seeking that puts diffuse interests, such as households, at a potential disadvantage. Industrial customers have important advantages in commission proceedings.

These findings also have potentially significant implications for the efficiency of wholesale markets. The intended design of wholesale markets, like PJM's RTO construct, is one in which least cost generation units are incentivized to produce in the short run, and long run efficiency is encouraged via price signals that incent efficient units to enter the market and inefficient units to retire. Recent literature has provided the theoretical understanding for how regulatory subsidization of generation units can have both short run and long run adverse efficiency consequences for wholesale markets (Dormady, 2017). These consequences would be borne out in the short run if Type II cross-subsidization allows utility-affiliated gencos to displace more efficient generation units in the unit commitment process. And, these consequences would be borne out in the long run if cross-subsidization delays efficient retirement decisions and discourages market entry by more efficient units. Moreover, if displaced units are more fuel efficient or lower emissions intensity units, Type II cross-subsidization could likely result in both short run and long run adverse environmental impacts as more energy-efficient units are displaced.

Retail deregulation was sold as a way to improve efficiency and lower prices to businesses and households. The results of this study indicate that restructuring mechanisms can create additional incentives for interested actors to intervene in the regulatory processes to protect their interests. This has resulted in a system of cross-subsidization that has had important equity consequences. Cross-subsidies to utility-affiliated corporations have more than cancelled out any favorable effects of retail choice, with the greatest adverse effects observed by households.

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Appendix A. (Online) Supplementary Figures

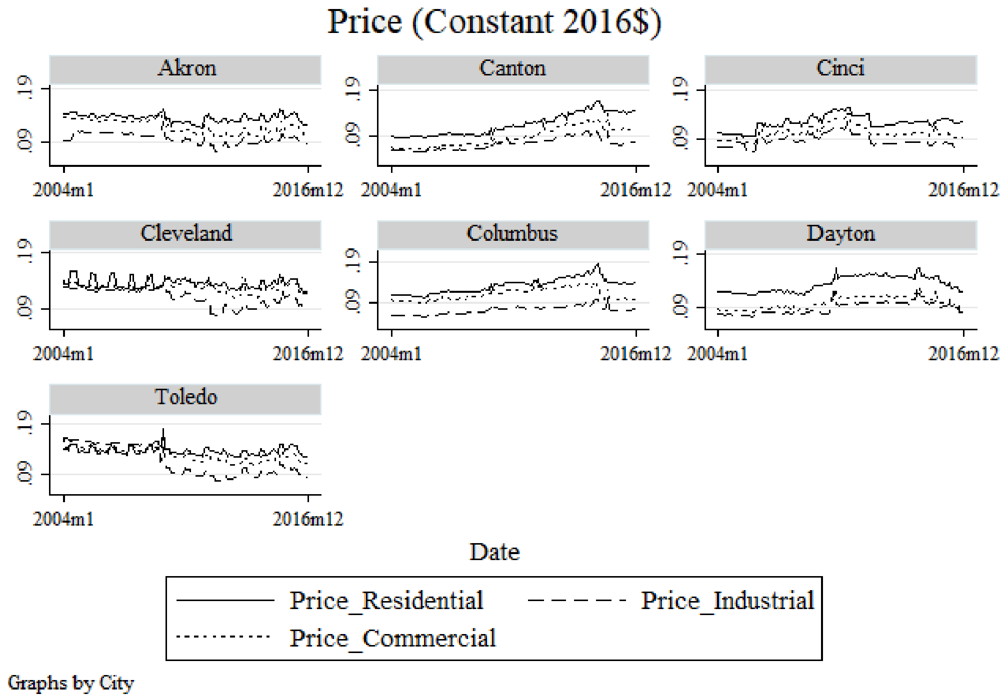

Figure A1. Marginal Price of Final Electric Bill (by class and metro area)
Note: Figure provides the monthly inflation-corrected marginal price by customer class for each of the seven major metro areas in the state of Ohio over the period 2004–2016.

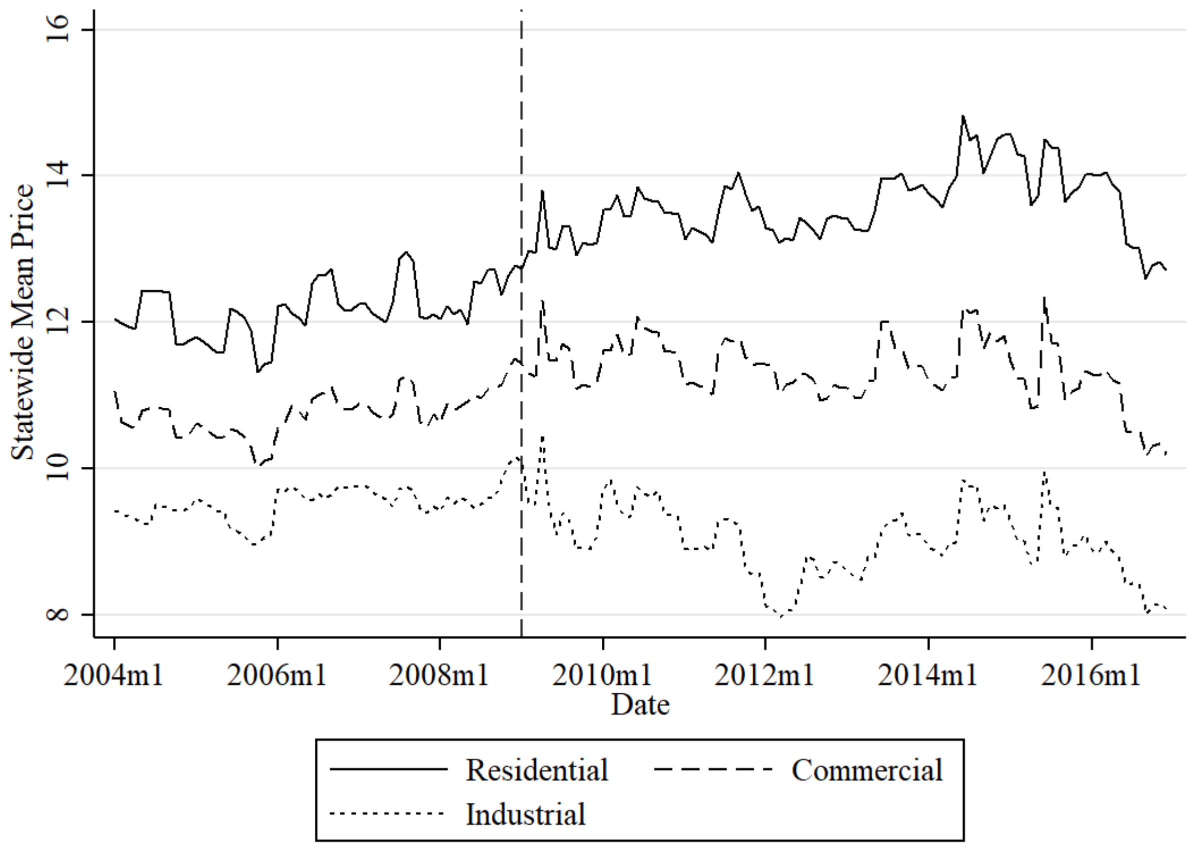

Figure A2. Statewide Mean Electricity Price

Note: Figure provides the mean monthly inflation-corrected statewide aggregate electricity prices by customer class. The vertical indicator bar identifies the implementation of retail electric restructuring beginning January, 2009.

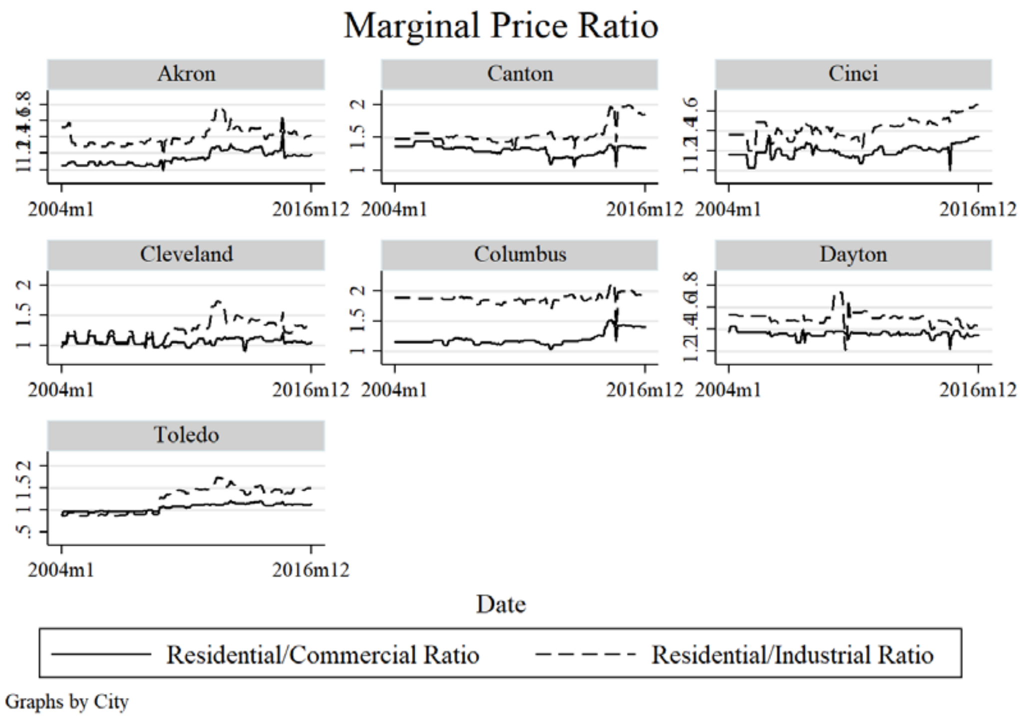

Figure A2. Inter-Class Marginal Price Ratios (by metro area)
Note: Figure provides the monthly marginal price ratios by major metro area.