Received: 3 July 2024 | Revised: 23 September 2024 | Accepted: 23 October 2024
DOI: 10.1002/jci3.12031

ARTICLE

Efficiency and consumer welfare under retail electricity deregulation: Analysis of Ohio's retail choice markets

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Funding information
Alfred P. Sloan Foundation, Grant/Award Number: G-2022-19460

Abstract
Many critical infrastructure services operate under either price regulation or deregulated systems. The grand policy experiment of deregulation has been heavily studied, but evaluations have been limited at the retail level where end-user prices are often difficult to obtain. This paper presents an in-depth look at the retail market for electricity in a retail deregulated, or restructured, market—Ohio. We build and introduce a comprehensive SQL database of every daily filed retail electricity offer over a 9-year period of study, over two-million records. We integrate this data with other external data sources and conduct a detailed descriptive analysis of market prices as observed by end consumers at the retail level. We find that the lion's share of "competitive" retail electricity choice offers are more costly to consumers than the utility's default service rate and have higher markups over the wholesale price, and we find that when prices exceed the default rate they do so by a considerably larger margin than when consumers observe savings. We also find that even well-informed consumers are able to find a welfare-improving rate relative to the default rate between only 43% and 59% of the time. We conclude with a discussion of implications and root economic causes of the efficiency and consumer welfare problems we observe.

KEYWORDS
deregulation, energy markets, retail choice, retail electricity

1 | INTRODUCTION

Critical infrastructure systems are inextricably linked to the markets in which they operate. Many critical infrastructures operate in designed, highly centralized markets defined by economies of scale and resultant natural monopoly.[1,2] These infrastructures are often vertically integrated and subject to rate of return regulation.[3–5] Some industries have also experienced degrees of deregulation.[6,7] [*]

Oftentimes *safety, security*, and *reliability* of these critical infrastructures are the primary focal points of critical infrastructure research. We highlight the importance of *efficiency* of the markets in which they operate, and its resultant impacts on social welfare. Economic efficiency is also important because it is intimately connected to economic resilience,[8,9] both for producers and consumers. Well-functioning markets send efficient price and investment signals, and recent scholarship has established that both consumers and producers are more resilient when price signals are efficient.[10,11] There is also a growing literature on the relationship

*See a list of Presidential Policy Directive 21 sectors at https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors.

between efficient market signals and wholesale electricity system resilience and reliability.[†] A key societal challenge, therefore, is addressing the factors that influence market efficiency for critical infrastructure systems in markets that are designed, highly centralized, and subject to a high degree of regulatory intervention.[‡]

The energy sector is arguably the best place to explore these challenges, as it embodies a full range of policy interventions across jurisdictions and over time, and because of its central importance to issues of security and resilience. This paper explores a well-known policy intervention—deregulation of retail energy markets—otherwise known as “retail choice” or “restructuring.” The efficiency impacts of energy restructuring have been long explored in wholesale electricity markets, but its efficiency in retail markets, where consumers and producers directly interact with the market, has only recently been subject to scholarly examination and increasing policy debate.[16,17] Under this policy intervention, a competition construct replaces a regulatory rate of return model for setting the generation portion of consumers' electric bills, while the transmission and distribution components remain largely set by regulatory processes.[18] In these markets, consumers can shop from among competing marketers to supply their generation, or they can retain a designated default, provider of last resort (POLR) service that is typically provided by the local monopoly distribution utility.[§]

This paper takes an approach that few have taken before, by viewing the evaluation of restructured retail markets from the standpoint of the consumer. It provides a detailed view of what the consumer observes, with a focus on efficiency and consumer welfare. Rather than providing a multistate or national study, this study dives more deeply into the consumer experiences in a single state, Ohio. We build the largest and most detailed database of retail electricity choice offers yet introduced in the literature, including millions of records that provide every daily public retail choice offer across every service territory in the state, across a 9-year period of study.[**] We provide a descriptive database analysis and compare retail market outcomes as observed by consumers engaging directly with the market. We compare the competitive retail electricity service (CRES) supplier offers with default service (also known as the standard service offer or SSO) prices provided by auction-based procurement through the regional regulated distribution utility.

The paper makes several important findings relating to the efficiency and consumer welfare effects of retail restructuring of this important infrastructure. We find that the lion's share of retail choice offers are welfare-inferior relative to the default service. Between 65% and 73% of competitive retail offers have historically exceeded the utility's default service rate, and the median retail choice offer has historically been about 10%–20% more expensive than the utility's default service. We find that historically, the magnitude (in terms of count, quantity, and price) of welfare-reducing offers exceeded the magnitude of welfare-improving offers. When retail choice offers exceeded the default service price, they did so by between 26% and 32%. When default service rates exceeded retail choice offers (i.e., customer savings), the savings ranged from 7% to 11%.

We also evaluate economic efficiency and consumer welfare by comparing these outcomes to wholesale energy prices. We find that historically, the median retail choice offer has been 98% higher than the wholesale energy price (i.e., about twice the price of the wholesale market), while the utility default price has been 73% higher than the wholesale energy price. Moreover, we evaluate temporal consumer welfare by identifying the count of days in which a residential customer, if going to the market to shop for retail electricity, could find an offer that would be welfare improving relative to the utility's default service. We find that in some years, consumers engaging in shopping experienced very few days in which they could access a rate leading to savings. Historically and across all years of study, customers could access welfare-improving offers during only 43%–59% of the year.

This paper is organized as follows. Section 2 provides a literature review of essential empirical work in this domain and provides helpful references to other more exhaustive literature reviews. Then, Section 3 provides the empirical and data analytic approaches used in developing and analyzing the database. Section 4 presents results, organized to present the frequency, magnitude, and temporal efficiency and social

[†]While this paper is about efficiency in restructured energy systems, retail efficiency can also indirectly impact grid security and reliability through mechanisms such as capacity markets that are closely impacted by retail market behavior,[12,13] and directly impact them through market entry and performance signals given through demand response and advanced metering infrastructure.[14]

[‡]Generally, for systems with externalities, market power, and asymmetric information, there is a rationale for regulation to address those issues. In terms of the objectives of wholesale market design (as distinguished from retail), part of the objective is to provide signals for efficient investment. See, for example, Cramton.[15]

[§]Fourteen jurisdictions in the US implemented retail electric restructuring: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Ohio, Illinois, Maryland, Washington, DC, and Texas. All these jurisdictions besides Texas offer widely-accessible default service. Note that several other states, including Virginia, Michigan, and California, have partially implemented retail electric restructuring. For a detailed and up-to-date summary of default procurement approaches across each state, see Hoyt et al.[19] Internationally, the United Kingdom, Sweden, Norway, Korea, Australia, New Zealand, and Canada, among other countries, have implemented variants of retail restructuring in at least a portion of their broader electricity market.

[**]Ohio restructured its retail electricity markets with the passage of SB3 (1999) and HB221 (2008). Dormady et al.[20] provide a helpful history.

welfare assessment. Section 5 provides a discussion of results, and Section 6 concludes.

2 | LITERATURE REVIEW

2.1 | Regulation versus deregulation: Consumer impacts

An important and growing body of literature has focused on the economic efficiency and consumer impacts of retail market restructuring (also known as retail choice or retail deregulation) by comparing it to vertically integrated, or regulated systems. This highly nuanced literature has been mixed in its assessment of consumer impacts. For helpful literature reviews on empirical work comparing the price impacts of regulated versus restructured markets, see Dormady et al.,[20] Bowen et al.,[21] or Su.[22] Much of the recent work cites a seminal Texas market study by Hartley et al.,[23] who find that restructuring increased efficiency, as measured by the difference between the wholesale and retail price. However, Dormady et al.[24] find that retail restructuring has had adverse impacts on consumer prices in their study of Ohio. Interestingly, the Hartley et al.[23] study confirms the Dormady et al.[24] finding that retail restructuring, as implemented, has unfortunately increased cross subsidies.

Both studies were later bolstered by Cicala[25] and Amenta et al.,[26] who confirmed that restructuring created an incentive for cross subsidies, shifting costs from deregulated market segments (i.e., generation) to regulated market segments (i.e., distribution) following restructuring's mandated divestiture of generation. Dormady et al.[24] refer to this as Type II cross subsidization—making up for lost generation rents by inflating distribution side of customer bills with riders and surcharges. However, Cicala's period of study predates most retail restructuring, and his panel ends before the actual divestiture requirements in states like Ohio. Amenta et al.'s European study appropriately finds that full retail restructuring does not exist as a pure policy instrument because distortionary regulatory involvement never actually goes away in entirety.

In a more recent study, Bowen et al.[21] conduct a midwestern US study comparing three regulated and three restructured states and find evidence of favorable consumer effects from retail restructuring. They also, however, confirm the Cicala,[25] Dormady et al.,[24] and Hartley et al.[23] findings (as well as Gultom[27]) relating to the adverse effects of cross subsidization following market restructuring. In other international market applications, Lee et al.[28] and Liu et al.[29] find restructuring reduced efficiency and led to increased consumer prices in Australia and China, respectively, while Loi and Jindal[30] find that retail restructuring led to lower consumer prices in Singapore.

2.2 | Restructured retail market prices and efficiency

The above literature compares regulated versus restructured markets, and it focuses more holistically on net consumer impacts. This current study is part of an even more nuanced and growing subfield of study that focuses entirely on the restructured retail market. It evaluates economic efficiency *within* the retail market. Brown et al.[31] and Esplin et al.[32] provide helpful and thorough literature reviews of this important subfield of study. Unlike the above literature that is ambivalent on whether consumers are net better off in restructured versus vertically integrated markets, the retail choice market subfield is rather unanimous in its assessment—finding generally that retail choice markets have some serious problems, and have, in the words of Puller and West,[33] p. 350 "replaced imperfect regulation with imperfect competition."

This subfield generally focuses on the competitiveness and efficiency of retail choice offers to consumers. Brown et al.[34] use data like that utilized in this paper, from the Texas Power to Choose retail choice customer shopping website, but for a much shorter period of study than what we use in this paper. They find evidence that retail supplier prices only pass through about half of the forecasted wholesale price change, and that retail prices are inflated by risk premia driven by forward implied volatility.[††] Simeone et al.[35] find evidence that retail suppliers' prices are highly marked up in their study of Pennsylvania's retail choice markets.

A growing body of studies within this subfield compares the efficiency and consumer impacts of the default price to retail choice offers.[35–38] This is our focus in this paper. These studies increasingly find evidence that retail suppliers set prices not on the basis of market fundamentals (e.g., the forward wholesale cost[‡‡]) as would be the case in an efficient market, but rather set prices based upon the default rate. Brown and Eckert[36] and Tsai and Tsai[38] in Alberta and Connecticut, respectively, both find evidence of price signaling by the default rate.[§§] Tsai and Tsai[38] (p. 283) go so far as to suggest that retail suppliers consider the

[††]Of note, unlike most other restructured states, Texas's POLR service is not designed to competitive outcomes. Rather, the POLR rate is deliberately priced at a premium as a way to induce switching.

[‡‡]Forward prices are often used by commodity traders, including those trading electricity. In theory, the forward price should be reflective of the minimum long-run average costs, though deviations can occur due to, for example, increasing marginal costs.

[§§]Interestingly, there are key differences between Ohio, Connecticut and Alberta in how the SSO price is set. Whereas Connecticut sets SSO prices by public bidding (requests for proposals or "RFPs") Alberta and Ohio both use auction-based procurement, with Ohio's auctions based upon a much longer forward period of procurement. See Dormady et al.[39] for details on how the default rate, or SSO, price is set in Ohio.

default rate a "competitor," and argue that "suppliers are pricing their products based on the rates of their main competitor, in this case the Standard Service [default rate]."[***]

Liquidity and competitiveness are also identified as core considerations in retail choice markets. As such, much of this research focuses on market concentration.[31,34,41,42] In the context of both Alberta and Texas, Brown and his colleagues document significant HHI measures in retail choice markets, and in Alberta specifically, they find that the top 3 firms control about 90% of the market share (see Table 1 in Brown and Eckert).[36] Concerningly, they find that the very same companies are dominant suppliers in both the default service and retail choice markets. Additionally, Brown et al.[31] document market concentration increasing over time as these markets mature.

An underdeveloped, yet important line of inquiry within this subfield has also begun to evaluate the type of suppliers participating in retail choice markets, comparing suppliers that do not own generation with those firms that are affiliated with a parent company that owns generation (known colloquially as "gentailers").[31,43] This literature finds that gentailers enjoy greater brand recognition and thus observe greater market power in retail choice markets because they effectively capitalize on a trifecta of consumer biases: customer inertia,[44–49] consumer inattention,[44,50,51] and brand recognition or "stickiness."[31] Brown et al.[31] find that gentailers use these demand-side effects to their advantage, inflating consumer prices rather than passing savings through to end consumers.

2.3 | Consumer behavior in retail choice markets

Because of the importance of demand-side effects in these markets, such as consumer biases, inattention, brand recognition, and inertia, there exists another growing subfield of literature relating to consumer behavior.[42,45,52–55] This literature focuses on explaining heuristic and decision-making biases (e.g., status quo bias) and how they impact behavior in these markets, identifying consumer switching rationales, and evaluating attributes of retail choice offers orthogonal to price that captivate consumers (e.g., renewable energy, perquisites). We refer readers to Ndebele et al.[53] for a helpful literature review on this topic.

***Tschamler[40] provides an excellent assessment of the importance of the SSO in providing a social safety net, or backstop, for customers.

3 | METHODOLOGY

3.1 | Data

All Ohio retail electric choice offers are required to be filed with the Public Utilities Commission of Ohio (PUCO) by registered retail choice providers using a commission web portal, and are viewable daily on a customer choice marketplace.[†††] Here, we built an SQL database consisting of every historical electric choice offer filed with the PUCO between 2014 and 2023.[‡‡‡] It contains details for each CRES supplier offer, for each day and by distribution utility service territory. In total, it contains 2,022,842 public residential offers, with an average of 92 offers each day for each of the six distribution service territories in Ohio.

The database consists of the marginal rate in cents per kilowatt-hour (kWh), the type of contract (fixed vs. variable rate offer), the contract length or maturity, the percentage of renewable content[§§§] associated with the offer (if any), any fixed monthly fee or flat rate component of the offer, any early termination fees, and text string fields describing details associated with the offer, promotional offer details, or perquisites offered with the contract. To extract this data, we evaluated the HTTP requests made when conducting a search via the website and observed the format of the JSON-based responses. We developed a series of tools using C# and Python to automate the submission of these requests, parse the received responses, and store that parsed data in a relational database (SQL).

That database was also merged with another database built from detailed historical tariff filings with the PUCO for each distribution utility, for each month or quarter, and for each rider included in the composite price to compare (PTC). This provided the source of the SSO PTC rates. This involved a human review of every generation rider, and data entries checked against historic generation rate bill data available through the PUCO Retail Rate Survey,[****] a historic record of all utility charges and all riders by customer class and utility type. Some cleaning of the historical retail choice offer database was required before analysis, which we performed with a Python cleaning script.[††††] Duplicate

†††"Energy Choice Ohio—Apples to Apples." PUCO, https://www.energychoice.ohio.gov/ApplesToApples.aspx, last accessed March 3, 2024. Ohio's site is similar to retail electric shopping sites in several other states, including Texas' Power to Choose[31] and Pennsylvania's PA PowerSwitch site.[35]

‡‡‡"Apples to Apples History Browser," PUCO, https://puco.ohio.gov/documents-and-rules/resources/a2a.

§§§Because CRES contracts are a financial instrument through PJM, the customers' renewable content is no different from the aggregate region-wide portfolio. Instead, supply offers report renewable content based on the purchase of renewable energy credits.

****https://puco.ohio.gov/utilities/electricity/resources/ohio-utility-rate-survey

††††This corrected issues of erroneous currency in data entry, mainly correcting for entries in cents (8.99) instead of dollars (0.0899). The script cleaned values based on thresholds mapping to the SSO PTC for reasonableness of rates given the historical range of rates at that time.

offers were eliminated from the database. Offers were automatically organized with unique ID numbers to enable duplicate offer downloads or postings to be screened out.[‡‡‡‡]

A separate data set of wholesale electricity generation prices was built and used for modeling and evaluation of the PJM Interconnection, LLC (PJM) wholesale energy price.[§§§§] This data set was cultured from S&P Market Intelligence wholesale market data and consisted of the day-ahead locational marginal price (LMP) for each of the four major residual aggregate pricing points within the Ohio wholesale service area that map directly to Ohio's six distribution utilities (American Transmission Systems Inc. for the three FirstEnergy utilities, DEOK for Duke Energy Ohio, Dayton Hub for Dayton Power & Light/AES Ohio, and American Electric Power [AEP] for AEP Ohio).[*****] Integration of these three databases allows for the evaluation of historical CRES, SSO, and load-adjusted wholesale prices that provide the time and load-adjusted wholesale marginal rate.

3.2 | Data analysis

The database was analyzed using SQL and R. In Ohio, there are six distinct territories denoted AEP (AEP Ohio),[†††††] Toledo Edison (FETE), Duke Energy Ohio (DUKE), The Cleveland Electric Illuminating Company (FECEI), Ohio Edison (FEOE), and Dayton Power & Light/AES Ohio (DPL).

To compare SSO and CRES rates across the same time intervals, and because SSO rates are set on a "delivery year" basis that runs from June 1 to May 31 of the next calendar year, we separate offers temporally by delivery year. This accounts for the way in which SSO PTCs are set via procurement auctions in which procured tranches are blended into a single annualized generation rate that changes each year on June 1. The tranche-adjusted auctions are blended into a single generation price, inclusive of additional bypassable riders, for the duration of that 12-month delivery year. This rate becomes the SSO PTC.

The calculation to determine the annual percentage of daily offers that exceed the SSO price—which, in the frequentist point of view, is regarded as exceedance probability—is performed using the following formula:

$$Prob_1 = \frac{1}{n}\sum_{i=1}^{n}\frac{N_1}{N_{\text{daily total}}} \times 100\%. \tag{1}$$

In this equation, N_1 represents the count of daily offers exceeding the SSO price, $N_{\text{daily total}}$ signifies the total number of CRES offers published in 1 day and n denotes the number of days within a year, typically 365 or 366 for leap years. The average percentage is denoted as $Prob_1$.

The calculation for the average ratio in price between the median daily CRES offers and the SSO price is conducted as follows:

$$R_1 = \frac{1}{n}\sum_{i=1}^{n}\frac{Price_{\text{median CRES}}}{Price_{\text{sso}}} \times 100\%, \tag{2}$$

where $Price_{\text{median CRES}}$ refers to the median price of daily CRES offers, while $Price_{\text{sso}}$ indicates the SSO price. Similar to Equation (1), n represents the number of days in a year. The notation R_1 is used to denote the average price ratio.

The calculation to determine the percentage of annual offers that exceed the SSO price, denoted by $Prob_2$, is performed using the following formula:

$$Prob_2 = \frac{N_2}{N_{\text{annual total}}} \times 100\%. \tag{3}$$

In this equation, N_2 represents the count of all daily offers exceeding the SSO price, across the whole delivery year, and $N_{\text{annual total}}$ signifies the total number of CRES offers published in one delivery year.

The calculation for the average relative difference of CRES prices from SSO prices for CRES offers above SSO prices, represented by R_2, is conducted as follows:

[‡‡‡‡]The raw data also included 450 CRES offers displaying a price of $9999/kWh. These offers shared a promotion offer detail of "residential, 10% discount off the price to compare." The cleaning script thus substituted the "9999" price in each of the 450 CRES offers with 90% of the SSO price in the month that the offer was published.

[§§§§]We note that both the CRES and SSO suppliers are required to provide "full requirements" services, which include energy, capacity, market-based transmission service, and market-based ancillary services. We note that transmission is not competitively priced in Ohio as it is in other states, such as Pennsylvania, and, as such, the relative comparison between SSO and CRES offers is unaffected by the absence of transmission costs in the wholesale price. Both CRES and SSO customers observe the same transmission rates.

[*****]The focus of this analysis is the relative difference between CRES and SSO rates historically. We incorporate wholesale costs to provide another lens through which to examine the relative differences between these two main retail rate mechanisms. We acknowledge that there are other wholesale costs additional to the LMP, including ancillary services, capacity, and renewable requirements. Using annual PJM Market Monitoring Report data, in a separate analysis not reported here, we conduct an annualized historical analysis from 2013 to 2023, to evaluate the total proportion of wholesale costs that are additional to the LMP. The sum total of all noncapacity, nonenergy, and nontransmission costs ranges from $1.34 to $2.83/MWh over the full review period. On a percentage basis, the annual costs represent between 1.9% and 4.4% of total wholesale costs. For RPS costs, these ranges are $0.05–$0.38/MWh and 0.1%–0.8%. In other words, using the LMP for purposes of a relative comparison and markup analysis omits only a very tiny proportion of the overall net wholesale cost.

[†††††]The AEP service territory included two separate distribution utilities that were merged in the second year of this database, in 2015. These consisted of Columbus Southern and Ohio Power Company, both owned by AEP. Premerger CRES offers were available across both utility territories and are not distinguishable in the database, as are the SSO PTCs. Where appropriate, analyses are performed separately premerger.

$$R_2 = \frac{1}{12}\sum_{m=1}^{12}\frac{\frac{1}{k}\sum_{i=1}^{k}(Price_{\mathrm{CRES>SSO}} - Price_{\mathrm{SSO}})}{Price_{\mathrm{SSO}}} \times 100\%, \quad (4)$$

where $Price_{\mathrm{CRES>SSO}}$ refers to the price of CRES offers above SSO prices in 1 month, while $Price_{\mathrm{sso}}$ indicates the SSO price of that month. k represents the number of above-SSO CRES offers.

The calculation for the average relative difference of CRES prices from SSO prices for CRES offers below or equal to SSO prices, represented by R_3, is conducted as follows:

$$R_3 = \frac{1}{12}\sum_{m=1}^{12}\frac{\frac{1}{l}\sum_{i=1}^{l}(Price_{\mathrm{CRES\leqslant SSO}} - Price_{\mathrm{SSO}})}{Price_{\mathrm{SSO}}} \times 100\%, \quad (5)$$

where $Price_{\mathrm{CRES\leqslant SSO}}$ denotes the price of CRES offers that are either below or equal to the SSO prices, in 1 month, while $Price_{\mathrm{sso}}$ represents the SSO price of that month. l signifies the count of CRES offers that fall below or equal to SSO prices.

4 | RESULTS

The results below are logically organized to present a descriptive summary of the efficiency and competitiveness of the Ohio retail choice markets from the consumer's vantage point. We begin by providing a historical summary of the overall prices in the CRES, SSO, and the wholesale day-ahead energy market over the period of study. We then provide detailed descriptive analyses of the frequency and magnitude of retail choice offers relative to the SSO. Following that, we provide a detailed summary of retail price markups relative to the day-ahead wholesale energy price. Then, we present a temporal frequency analysis to show how many days out of the year consumers are able to obtain savings relative to the SSO.

4.1 | Time series of retail and wholesale prices

We begin by presenting a time series plot (Figure 1) of retail prices for the SSO PTC alongside the daily median CRES rate for 2014–2023. Because there are about a hundred CRES offers in each service territory daily, here we begin by representing the median CRES offer in the series. The monthly CRES median represents the median value calculated for each month based on the daily median prices. We also present the wholesale energy price for each distribution utility's zonal wholesale market on the primary *Y*-axis for illustrative comparison, as well as to inform subsequent analyses below relating to price markups relative to the day-ahead price. Supporting Information Appendix A provides historical values for distributional parameters at the 5th and 95th percentiles of prices.

Historically, wholesale energy prices were on a precipitous decline coincident to the US Shale Boom. Retail prices responded to those declining wholesale prices, and generally we observed a backwardated market (i.e., lower future price than current price) between 2016 and 2020. During that time, retail generation prices for both the CRES and SSO declined precipitously, and the SSO generally provided more stable and more social welfare-improving rates to the residential consumer than the median CRES offer. After 2020 however, consumer outlook was fundamentally altered by dramatic changes in national energy priorities, the Covid-19 pandemic, and a rise in global energy prices associated with the Ukraine War which followed almost immediately after European crude oil prices rose above $100/barrel.

Because the SSO price is lagged by the auction procurement structure used to set its PTC (see Dormady et al. 2024 for a detailed description of how the SSO PTC price is set), it was slow to respond to an itinerant and rapidly increasing wholesale price and did not adjust until 2022 and 2023 in some service territories. During that time, the SSO provided consumers with yesterday's favorable prices today, providing an overall welfare gain to retail consumers and temporarily shielding them from national and global energy shocks. In the very last year of our series (2023), SSO prices remained high, while the more responsive CRES prices were able to at least partially return to their pre-energy shock levels. In all territories, the median CRES offer during 2023 provided a welfare-improving option for consumers relative to the SSO, which had not yet resettled.

4.2 | Frequency of competitive CRES offers

To evaluate the relative performance of CRES offers relative to the SSO, we first evaluate the frequency (%) of daily CRES offers that exceed the SSO. Table 1 reports this frequency for 12-month (most common), fixed-rate residential offers. Table 2 provides the same assessment for all maturities, including the 12-month products. They report the value of $Prob_1$ from Equation (1). For example, in the Duke service territory (Cincinnati Metro Area) across all days in the 2017 delivery year, 84.1% of all daily 12-month maturity fixed-rate residential CRES offers were above (higher price in cents/kWh) the SSO PTC. The average percentages across all entities are provided at the bottom of the table. The overall average suggests that, historically, between 65% and 73% of the CRES offers

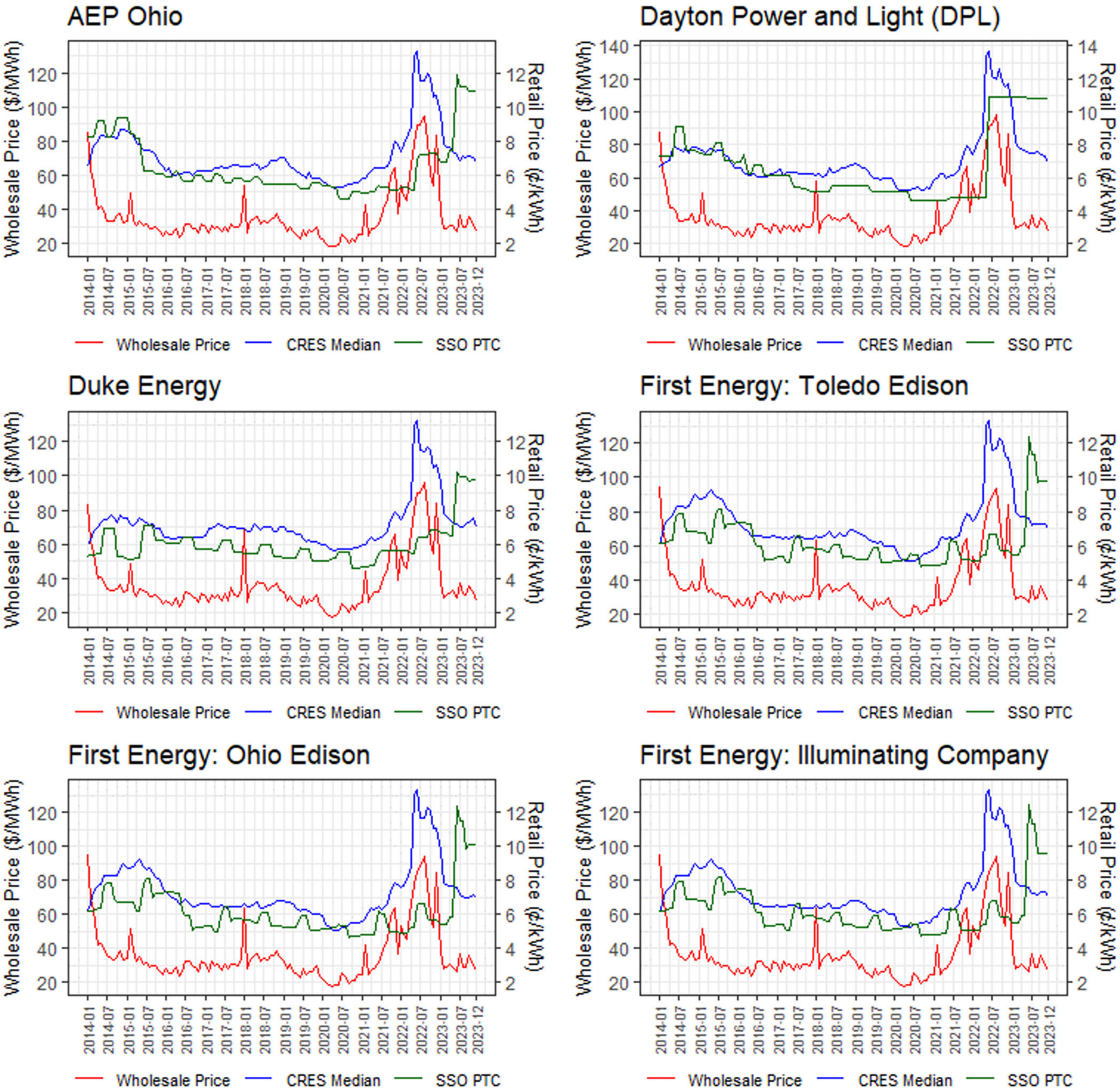

FIGURE 1 Wholesale and retail price by distribution utility (2014–2023). Time series of zonal wholesale price for PJM on primary *Y*-axis. The time series of daily SSO and the daily median CRES offer provided on the secondary *Y*-axis. Values are provided in nominal US dollars. AEP, American Electric Power; CRES, competitive retail electricity service; PTC, price to compare; SSO, standard service offer.

have marginal rates (cents/kWh) that exceed the default SSO rate. These values are 57%–70% when the other maturity offers are also included in the analysis. We similarly conducted an analysis using McCrary[56] density tests, to evaluate the degree to which the SSO is treated by some CRES suppliers as a possible price floor for some consumer segments. See Supporting Information Appendix C for results and details.

Generally, these historical values show that the majority of CRES offers have been less competitive and less favorable to the consumer in terms of price and marginal rate than the SSO. Year-to-year fluctuation in these frequency values is a function of the fact that CRES offers can be changed or modified daily, responding to wholesale markets more readily, whereas the SSO price, which is set by procurement auctions, is fixed for a 12-month delivery year several months in advance of that delivery. The largest deviations in the overall net effect occurred in the last delivery year on record (DY2023), in which SSO advance procurement auctions held during a highly volatile market (e.g., Nord Stream II, Ukraine War) in

TABLE 1 Frequency (%) of CRES offer rates exceeding the SSO (12-month maturities).

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	18.3	53.0	51.1	92.3	94.6	95.0	94.6
2015	79.9	79.9	39.3	68.2	62.1	65.1	64.4
2016	73.3	73.3	45.1	75.5	89.4	92.3	91.1
2017	75.7	75.7	87.9	84.1	67.5	71.9	70.3
2018	86.1	86.1	86.8	86.2	81.9	82.8	83.7
2019	62.1	62.1	66.4	70.6	65.4	63.2	64.1
2020	76.1	76.1	79.3	78.2	71.7	71.9	70.1
2021	88.4	88.4	96.0	88.5	84.2	86.1	85.0
2022	89.1	89.1	51.3	94.7	98.0	98.0	97.8
2023	3.5	3.5	6.6	5.9	5.8	4.6	5.8
Average	**65.3**	**68.7**	**61.0**	**74.4**	**72.1**	**73.1**	**72.7**

Note: Includes 12-month maturity, fixed-rate residential offers.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

TABLE 2 Frequency (%) of CRES offer rates exceeding the SSO (all maturities).

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	16.8	51.6	38.5	88.1	87.7	88.9	88.2
2015	80.0	80.0	45.2	68.3	63.0	67.4	67.1
2016	68.3	68.3	52.2	72.0	86.2	88.5	88.2
2017	71.3	71.3	89.7	74.9	59.2	63.4	60.8
2018	84.3	84.3	81.0	82.6	78.8	78.4	80.6
2019	54.8	54.8	59.9	63.6	58.8	58.6	58.5
2020	71.2	71.2	72.6	69.3	65.8	67.2	64.8
2021	86.7	86.7	94.0	83.2	81.1	83.6	80.9
2022	85.4	85.4	38.5	93.9	96.8	97.4	97.7
2023	2.6	2.6	2.8	8.0	6.7	4.6	5.9
Average	**62.1**	**65.6**	**57.4**	**70.4**	**68.4**	**69.8**	**69.3**

Note: Includes fixed-rate residential offers of any maturity.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

calendar year 2022 set the DY2023 SSO PTC. When energy prices in 2023 rebounded to historically lower levels, the lag in the readjustment of the SSO made the SSO temporarily a welfare-reducing option for consumers.

4.3 | Magnitude of competitive CRES offers

We next evaluate the historical magnitude of CRES offer rates relative to the SSO. That is, how much more costly are CRES rates than the SSO? Table 3 provides historical average magnitudes of the daily medians of CRES offers, relative to the SSO on that day, focusing on 12-month maturity fixed-rate residential offers. It reports values for R_1 derived from Equation (2). We use daily medians to represent the distribution of daily CRES rates. For example, in the Cleveland Electric (FECEI) service territory in DY2016, on average, the median daily CRES offer was 119% of (or 19% more expensive than) the SSO rate. The overall average percentages across all entities from 2014 to 2023 indicate that the median choice offers were typically about 10%–20% above the SSO. Table 4 broadens the analysis to include all maturities among fixed-rate

TABLE 3 Magnitude (%) of 12-month CRES offer rates exceeding the SSO.

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	90.7	100.0	98.1	131.0	124.0	126.0	125.0
2015	110.0	110.0	96.8	105.0	103.0	105.0	105.0
2016	107.0	107.0	98.5	112.0	119.0	122.0	121.0
2017	114.0	114.0	119.0	121.0	108.0	112.0	110.0
2018	122.0	122.0	120.0	125.0	121.0	121.0	123.0
2019	107.0	107.0	110.0	114.0	111.0	110.0	110.0
2020	117.0	117.0	123.0	120.0	116.0	115.0	115.0
2021	149.0	149.0	162.0	140.0	144.0	148.0	142.0
2022	142.0	142.0	97.4	153.0	173.0	176.0	176.0
2023	62.8	62.8	68.5	72.7	69.8	66.6	69.2
Average	**110.0**	**111.0**	**108.0**	**120.0**	**118.0**	**120.0**	**119.0**

Note: Includes 12-month maturity, fixed-rate residential offers. Values provide the mean of daily medians across all 365 days in the delivery year.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

TABLE 4 Magnitude (%) of CRES offer rates of all maturities exceeding the SSO.

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	90.1	99.4	95.2	128.5	121.2	122.8	122.9
2015	112.0	112.0	98.9	107.3	102.3	104.4	104.3
2016	105.2	105.2	100.8	108.0	117.4	120.3	119.1
2017	108.7	108.7	116.4	112.2	104.0	106.4	105.3
2018	117.7	117.7	115.7	119.5	116.0	115.7	117.9
2019	103.1	103.1	105.9	108.0	106.0	105.1	105.4
2020	110.9	110.9	116.2	112.5	110.5	111.5	110.2
2021	139.4	139.4	154.8	132.9	137.0	140.9	135.0
2022	135.4	135.4	92.7	149.1	165.3	167.9	167.7
2023	62.4	62.4	67.0	72.7	67.9	65.7	67.5
Average	**108.5**	**109.4**	**106.4**	**115.1**	**114.8**	**116.1**	**115.5**

Note: Includes fixed-rate residential offers of any maturity. Values provide the mean of daily medians across all 365 days in the delivery year.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

residential offers. Among all maturities, we find similar results though with slightly smaller magnitudes.

Interestingly, we observe a historical trend of increasing magnitudes over time, abrogated of course by the post-Covid, wartime economy carrying over into 2022 and 2023. This indicates that while the retail market continued to develop and expand, and while the wholesale market was backwardated and declining in price, the propensity of CRES suppliers to offer contracts exceeding the SSO has increased over time. In other words, while the wholesale market was delivering year-over-year decreases in prices, CRES suppliers were increasingly offering less competitive products to residential customers.

4.4 | Net frequency of competitive CRES offers

Because of seasonal variation in wholesale prices and associated differences in peak versus shoulder seasons, the frequency numbers represented in Tables 1 and 2 can be evaluated another way, using the net of all offers across the DY. In other words, if we lump all

TABLE 5 Net annual frequency (%) of CRES offers exceeding the SSO.

Delivery year	AEP CSP	AEPOP	DPL	DUKE	FECEI	FEOE	FETE
2014	14.7	26.2	76.1	97.8	100.0	100.0	100.0
2015	70.5	70.5	44.5	80.7	65.8	66.4	63.0
2016	75.5	75.5	61.8	76.8	82.9	87.7	83.1
2017	93.5	93.5	100.0	93.3	85.7	96.2	89.5
2018	92.2	92.2	94.7	84.1	88.5	88.5	87.2
2019	54.3	54.3	44.5	47.7	52.4	46.8	39.1
2020	69.4	69.4	64.4	70.4	62.7	58.9	57.6
2021	91.9	91.9	94.6	87.8	80.1	82.6	81.2
2022	87.2	87.2	39.4	98.5	100.0	100.0	100.0
2023	0.0	0.0	0.0	0.0	3.5	0.6	3.3
Average	**72.1**	**73.4**	**68.9**	**81.9**	**72.2**	**72.8**	**70.4**

Note: Includes 12-month maturity, fixed-rate residential offers.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

offers across the whole delivery year into a basket (or net across the entire year), what percent of those offers on net exceed the SSO?

The values in Table 5 represents $Prob_2$ derived from Equation (3), among 12-month fixed-rate residential offers. For example, in the AEP service territory (Columbus Metro Area and central Ohio) during the 2018 delivery year, of all the 12-month fixed-rate residential offers listed in that year, 92.2% of the offers exceeded their corresponding SSO rate. The historical average of these values across all years was between 68.9% (DPL territory was the lowest) and 73.4% (AEP territory was the highest). Put another way, historically, at best, only about 30% of the CRES offers were welfare improving relative to the SSO for residential consumers.

Overall, the results in Table 5 are similar to the frequency values provided in Tables 1 and 2. However, as evaluated here across the entire year rather than the daily assessment, we observe considerably more variation in the frequency of welfare-improving rates, both across utilities within the same time period and across time.

A significant decline in the proportion of offers exceeding the SSO is observed in DY2019 and DY2020, as presented in Table 5. The percentage of 12-month fixed-rate residential offers in the AEP service territory that exceeded the SSO dropped considerably to 54.3% in DY2019 from 92.2% in DY2018. This decrease coincides with some of the lowest SSO procurement auction prices of all time. All SSO procurement auctions in 2019 and 2020 were in the $30–$40/MWh range (3–4 cents/kWh). At this same time, there was a marked increase in CRES suppliers entering the market, which is a proxy for increased retail competition, as depicted in Figure D1 (referenced in Supporting Information Appendix D). Notably, the entry of more supplier companies into the electric market began around the calendar year 2019. Additionally, the upward trend in the net annual frequency of CRES offers surpassing the SSO in DY2021 aligns with the market dynamics illustrated in Supporting Information Figure D1.

4.5 | Rate markup and savings magnitudes

Given these frequency and magnitude results, we can also evaluate the magnitude of CRES offer markups. That is, among the welfare-reducing CRES offers, how much more costly are they than the SSO? Likewise, among the welfare-improving CRES offers, how much less costly are they? Or, put another way, when consumers see savings, by how much? And, when consumers see more costly offers, by how much?

These results are provided by calculating R_2 as provided in Equation (4). They are provided in Tables 6 and 7. For purposes of these calculations, offers with positive (cost-incurring) monthly fees (fixed-rate components), renewable fees, or early termination fees are not included. As such, these values present a best-case scenario, and including those additional costs would demonstrate more extreme welfare-reducing results.

For example, in the Toledo Edison (FirstEnergy) service territory, among welfare-reducing CRES offers that exceeded the SSO in DY2019, the average CRES rate exceeded the SSO by 56.9%. The historical average across all years ranged from a 26.4% markup (AEP) to a 32.9% markup (FirstEnergy). And among the welfare-improving CRES offers that were exceeded by the SSO, the historical average across all years ranged from 7.8% savings (Duke) to 11% savings (DPL).

TABLE 6 Magnitude of rate markup (%) among CRES offers exceeding the SSO.

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	3.9	9.4	6.7	42.2	24.5	22.9	22.6
2015	10.6	10.6	13.8	9.5	9.7	12.1	11.0
2016	11.1	11.1	11.1	12.2	24.4	27.0	25.9
2017	22.0	22.0	27.9	15.6	20.6	19.8	20.2
2018	22.0	22.0	22.8	21.2	24.6	24.4	25.9
2019	34.5	34.5	55.1	40.7	46.1	48.2	56.9
2020	30.5	30.5	42.2	29.2	44.9	40.3	43.6
2021	50.8	50.8	64.5	39.6	47.9	50.8	44.8
2022	52.5	52.5	19.4	55.7	81.0	80.2	79.9
2023	0.0	0.0	0.0	0.0	5.0	16.8	4.4
Average	**26.4**	**27.1**	**29.3**	**29.6**	**32.9**	**34.3**	**33.5**

Note: Includes 12-month maturity, fixed-rate residential offers.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

TABLE 7 Magnitude of rate savings (%) among CRES offers below the SSO.

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	−14.8	−7.1	−11.8	−6.0	0.0	0.0	0.0
2015	−5.5	−5.5	−7.7	−5.3	−13.7	−10.5	−11.9
2016	−2.9	−2.9	−10.6	−6.2	−4.1	−3.8	−3.6
2017	−3.2	−3.2	0.0	−3.4	−3.1	−2.9	−3.1
2018	−1.4	−1.4	−4.0	−2.4	−3.9	−4.0	−3.4
2019	−10.3	−10.3	−9.4	−8.2	−11.4	−11.2	−10.4
2020	−8.7	−8.7	−4.9	−7.7	−8.0	−7.0	−8.1
2021	−6.5	−6.5	−3.0	−8.4	−9.8	−8.2	−10.3
2022	−6.4	−6.4	−13.8	−1.8	0.0	0.0	0.0
2023	−36.6	−36.6	−34.1	−28.9	−34.0	−34.8	−35.0
Average	**−9.6**	**−8.8**	**−11.0**	**−7.8**	**−11.0**	**−10.3**	**−10.7**

Note: Includes 12-month maturity, fixed-rate residential offers.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

Evaluating the data this way highlights the differential impact of CRES markets relative to the SSO. While the previous results clearly showed that the lion's share of CRES offers were above the SSO in terms of both frequency and magnitude, these results demonstrate that when the choice offers are more favorable than the SSO, their welfare-improving magnitude represents about a 10% savings historically. But, among welfare-reducing offers, the additional markup is historically about 30%. Put another way, the historical magnitude of cost-saving offers is about one-third the historical magnitude of welfare-reducing offers.

Also of note, the results in Table 6 demonstrate the same welfare-reducing trend across time, with the magnitude of these differentials in CRES offers above the SSO increasing with time, excepting for the most recent post-Covid delivery year. Between 2014 and 2018, the markups were in the 10%–20% range above the SSO, whereas after 2018, markups essentially doubled. A proportionate trend in the cost-saving CRES offers is not identified in the data.

We also evaluate the historical markup relative to the wholesale market as another point of comparison. Using the PJM monthly average day-ahead residual aggregate price (day-ahead market), we compare the overall historical markups of the CRES and SSO retail prices between 2014 and 2023. These results are provided in Table 9. They offer another way to assess retail markups, by providing the overall historical cost margin of the generation price for retail electricity relative to the cost of generation. We note that, within that markup relative to the wholesale energy price, there exist additional costs of servicing both CRES and SSO customers that are not included in this analysis. These include load risk premia, and any forward hedging costs. Using AEP as an illustrative example, over this 10-year lookback period, their historical average load-weighted wholesale energy price stood at $35.60 per megawatt-hour (MWh), or equivalently, 3.56 cents/kWh. This represents the cost of generation alone, and excludes capacity, ancillary services, and so forth. By contrast, their SSO retail price was 81.7% above the wholesale price (at 6.47 cents/kWh). And, for residential consumers in their service territory, the median CRES contract rate was 99.4% above the wholesale energy price (at 7.1 cents/kWh). Equivalent values for the other service territories are provided in Table 8. The table also provides the overall net statewide total averaging across the six distribution service territories. We note that this statewide average may be slightly different if it were adjusted by load, customer count, or other comparative factors.

Historically, the SSO has provided residential customers with a 73.4% markup above the wholesale energy price, and the CRES market has provided residential customers with a 98.9% retail markup (about twice the price). The markups are broadly similar across service territories and roughly equal within the three FirstEnergy utilities, which have the largest CRES markups but some of the lowest SSO markups. Historical correlations between these markets are provided in detail in Supporting Information Appendix B, and generally indicate that the CRES market is more highly correlated with the wholesale market, which is intuitive because it can more readily respond to price changes than the SSO.

However, this pattern indicates that while the CRES market is more closely correlated to the wholesale prices (i.e., fluctuating with market conditions), it does not necessarily translate to more efficient or cheaper retail prices for the consumer. Despite the competition within the CRES market, the median offer has been about twice wholesale price, while the SSO has been about 14% below that and has historically been the more favorable pricing mechanism for consumers relative to the median CRES offer.

4.6 | Temporal frequency of available cost-saving CRES offers

From a consumer's vantage point, the availability of cost-saving offers is of critical importance. Since most consumers are not expected to be day traders, checking and evaluating complex market dynamics daily to maximize utility and minimize cost, it is of key societal importance to answer the question of how often within a given delivery year a residential consumer can find welfare-improving CRES offers if they search the open market each day. Or, put another way, when how often can consumers "catch" a welfare-improving CRES offer?

To address this, we estimate R_3 from Equation (5), as provided in Table 9. Within each distribution utility and delivery year, we find the number of days in the 12-month delivery year in which a consumer could find any CRES offer with a rate below the SSO. For example, in the Cleveland area (FirstEnergy) in DY2015, a consumer shopping every day for the full year would be able to identify at least one CRES offer that was below the SSO for 218 days out of the year (or about

TABLE 8 Net historical markups by distribution service territory (2014–2023).

Distribution Utility	Average wholesale energy price (cents/kWh)	Average SSO price (cents/kWh)	Average daily median CRES price (cents/kWh)	SSO/PJM markup (2014–2023) (%)	CRES/PJM markup (2014–2023) (%)
AEP	3.56	6.47	7.10	181.742	199.438
DPL	3.68	6.70	7.08	182.065	192.391
DUKE	3.61	5.98	7.13	165.651	197.507
FECEI	3.62	6.20	7.28	171.271	201.105
FEOE	3.62	6.14	7.28	169.613	201.105
FETE	3.62	6.17	7.30	170.442	201.657
Statewide Average	**3.62**	**6.28**	**7.20**	**173.464**	**198.867**

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; SSO, standard service offer.

TABLE 9 Availability of cost-saving CRES offers (count of days per year).

Delivery year	AEP CSP	AEP OP	DPL	DUKE	FECEI	FEOE	FETE
2014	364	364	125	13	0	0	0
2015	218	218	334	221	218	218	218
2016	294	294	362	356	211	183	211
2017	99	99	0	68	110	67	88
2018	146	146	86	154	179	179	179
2019	361	361	364	364	364	364	364
2020	363	363	363	363	363	363	363
2021	126	126	97	133	122	122	126
2022	85	85	365	21	0	0	0
2023	214	214	214	214	214	214	214
Average	217	217	215	173	162	158	160

Note: Includes 12-month maturity, fixed-rate residential offers with zero monthly fees. Values provide the count of days (out of 365 days in a delivery year) on which a residential consumer could find any CRES offer of 12-month maturity (equivalent maturity to the SSO) with a rate below the SSO.

Abbreviations: AEP, American Electric Power; CRES, competitive retail electricity service; CSP, Columbus Southern Power; DPL, Dayton Power & Light; DUKE, Duke Energy Ohio; FECEI, The Cleveland Electric Illuminating Company; FEOE, Ohio Edison; FETE, Toledo Edison; OP, Ohio Power; SSO, standard service offer.

60% of the days in the delivery year). The historical averages across all years range from about 160 days (FirstEnergy territory was the least favorable) to 217 days (AEP). In the FirstEnergy service territories, historically, residential consumers could find a welfare-improving CRES offer only about 2 out of every 5 days (or about 40% of the time).

Of note is DY2022, when we observe considerable heterogeneity between service territories. In that year, DPL's SSO rate was inflated by Covid-era high energy prices that remained high long after the wholesale market became less volatile. DPL held their forward SSO procurement auctions in April and November of 2022, that set-in place 85% of the total SSO rate for 2022 and 2023 procurement years. These auctions resulted in prices that nearly doubled from DPL's previous auctions. Consequently, in DPL, the unusually inflated SSO rate resulted in welfare-improving CRES offers available on the open market every day throughout the entirety of that delivery year. This does not reflect unusual savings in the CRES market, but rather unusual cost increases in the SSO. See Dormady et al.[39] for a detailed analysis of the history of auction-based SSO procurement. Similarly, in DY2022, we observe the absence or near absence of any available cost-saving CRES offers for residential customers in the other utility service territories.

An additional caveat is important to highlight regarding the results in Table 9. The analysis presented here removes offers with nonzero monthly fees (i.e., fixed-rate components). We do this because, in Ohio as in several other states, we observe frequent occurrences of fixed-rate offers of zero marginal price (zero cents per kWh) that include contractual obligations that cap monthly usage at lower than 80% of the statewide average. These gimmicky offers with $0.00/kWh rates include extremely low consumption caps and high monthly fees. As of the date of this writing, these zero cent offers are populating with $90 monthly fees and consumption caps of 692 kWh/month (about 25% below the average Ohio household). From review of the contract offer details, these retail rates can incur cost penalties on consumers if the cap is exceeded. Moreover, for those not exceeding the cap, the actual marginal rate of these offers presently works out to be about 14 cents/kWh (more than 300% above the current market rate). The results presented in Table 9 exclude these types of offers.

5 | DISCUSSION OF RESULTS

The findings of this paper's descriptive analyses motivate several important discussions. First and foremost, they raise key questions relating to efficiency and social welfare in the markets that price the important critical infrastructure service of electricity. Standard economic theory would suggest that in a competitive market, prices should be equal to or converge toward long-run marginal costs, and that uncompetitive supply offers that greatly exceed a competitive price should not be able to persist (see Hviid and Price[57] for a discussion of what an efficient price should be in retail choice markets). Retail electricity involves retailing a homogeneous product, electricity, procured from wholesale markets that are designed to use uniform price auctions at the nodal level[43,50] where the Law of One Price should arguably apply, excepting for small differences in service costs to consumers on account of transmission congestion and losses. However, our findings suggest that in these "competitive" markets (note "competitive" is the "C" in CRES), the majority of retail supply offers greatly exceed the default service price, and that a great dispersion in prices continues to persist over a decade or longer. Very expensive, overpriced supply offers abound, well above the market median or average retail price. This is not price convergence toward the marginal cost. This represents a persistent and consistent departure from standard economic theory.

Moreover, Hartley et al.[23] find that retail choice led to a decrease in the retail price relative to the wholesale price, which is a standard approach to evaluating efficiency. However, this result is contrasted with our findings, as we find that the retail price and the wholesale energy price remain consistently disparate, and that markups of the median CRES offer are considerably larger than default service. The critical distinction to make between the Hartley et al. study and this study is that Texas has a very different default service construct[‡‡‡‡‡] and Ohio has an auction-based SSO. This is important because Simshauser's[37] excellent study of the Australian markets finds that the default rate, especially in how it is presented to consumers as a "price to beat" (or "price to compare [PTC]" in Ohio), can be largely distortionary. However, in Australia, the PTC is not set by auctions or by a commission as in the US markets. Rather, retail suppliers set their own PTC and Simshauser describes manipulations in the manner by which it has been set historically. This level of distortion arising from the SSO, therefore, would not explain the departures from standard economic theory in Ohio.

Another potential explanation for the departure from standard economic theory observed in Ohio may be the persistence of another type of distortionary effect associated with the SSO as hinted at by Tsai and Tsai[38] and Brown and Eckert.[36] That is, CRES suppliers may be using the SSO as a price signal, or pricing based upon the SSO rate. Tsai and Tsai argue that the SSO is essentially treated by CRES suppliers as the "main competitor" (pp. 282 and 283). However, Tsai and Tsai argue that this causes the CRES suppliers to adjust their prices toward the SSO, as they find that the SSO explains greater variance in retail offers than the underlying wholesale price. This would tend to suggest, however, that retailers would face pressure to avoid posting highly priced offers 200%, 300%, or 400% above the market median as we observe with regularity and persistence in Ohio. Here, we do find considerable evidence confirming that many retail offers are priced based on the SSO PTC (see statistical significance values in Supporting Information Appendix C). However, this does not fully explain the magnitude and frequency of welfare-reducing offers, especially those priced significantly above the SSO (e.g., the many 16 cents/kWh offers available during the period that the SSO was around 4.5 cents).

Another line of research may also provide a competing explanation. This line of inquiry would suggest that the market distortion is not on the supply side, but rather on the demand side, due to market inertia and "stickiness"[44–49,58] and consumer inattention.[44,50,51] This line of inquiry would tend to suggest that consumers are ill-informed, unaware of market fundamentals, and consequently, CRES suppliers can sell these products because of inherent and persistent information asymmetries. This line of inquiry has also evoked issues of social justice and distributional equity, see, for example, Kahn-Lang.[50]

We offer a complementary argument to this line of inquiry. We agree that there are many demand-side shortcomings, including inherent and persistent consumer information asymmetries, inertia, and inattention. But we also pay considerable attention to the many legal actions and regulatory interventions that have taken place in these markets, in which regulators and offices of state attorneys general have intervened into these markets because of manipulations, illegal, unlawful, and untoward actions by CRES suppliers. Baldwin and Felder[16] provide a terrific discussion of many of these supplier-side market manipulations, and consumer abuses. We agree with Baldwin and Felder's assessment. Put simply, we argue that the issue is opportunism; CRES suppliers exploit known demand-side shortcomings and information asymmetries on the part of consumers.

Consider just a few examples in the past 4 years in Ohio. In 2020, the PUCO opened investigations into PALMco Energy after receiving many complaints of customers being enrolled into rates they were told were "competitive" and "the best" rates but were more than four times higher than the SSO.[§§§§§] The PUCO eventually revoked PALMco Energy's license to sell energy in Ohio as well as ordered large fines and customer refunds. In 2020, the PUCO opened an investigation into SFE Energy for manipulating and misleading sales practices, including falsely stating that the sales agent was at the home to do a utility check, using false information to access a customer's bill (e.g., obtaining a customer's secure account number to enroll them without their knowledge), making false claims about rates changing because of Covid-19, and failing to leave when asked to leave by the resident.[******] SFE

‡‡‡‡‡For helpful information regarding Texas' default service construct, see https://www.puc.texas.gov/consumer/electricity/polr.aspx

§§§§§See PUCO Docket, Case No. 19-2153-GE-COI.

******See PUCO Docket, Case No. 20-1216-GE-COI.

was subsequently penalized by the PUCO. The PUCO has also opened similar cases against Ambit Energy,[††††††] Direct Energy,[‡‡‡‡‡‡] Xoom Energy,[§§§§§§] and SmartEnergy Holdings LLC,[*******] for deceptive sales practices, enrolling customers in plans without their knowledge, and/or rolling customers over onto rates that were orders of magnitude above the SSO. In October of 2023, the PUCO ordered a $1.4 million forfeiture for RPA Energy for numerous violations including forged customer signatures, nondisclosure of monthly fees, misleading statements, and unauthorized third-party verification needed to authorize enrollment into the CRES contract.[†††††††]

We argue that the demand-side arguments fall short of telling the whole story. It is not the consumer's fault for being inattentive or unaware of the details of the market. We believe that the customer engagement, inattention, and inertia arguments are important and tell part of the story, but not all of it, particularly given the fact that social scientists have recognized the opposing "frameworks" through which consumers and utility providers view electricity provision.[59,60] As our analysis shows, even a well-informed consumer who shops for energy dozens of days out of the year would have difficulty most of the time finding competitive choice offers. Thus, a more comprehensive understanding of retail electricity markets must also take into account the high level of misconduct and deception on the part of profit-maximizing retailers.

We also argue that there are inherent supply-side failures that are different from the other supply-side arguments presented above. There exists a well-established literature on market failures in markets for resale products.[61–63] This literature demonstrates well-established market failures in markets for the resale of homogeneous goods, such as automobiles, financial products (e.g., mortgages), or concert tickets. In these markets, just as in retail electricity, innovation is inherently constrained. Standard economic theory suggests that innovation, or productivity improvements, are essential for efficient long-run production. However, in resale markets of homogeneous products, the product cannot be improved upon and can only be resold. Innovation is constrained. It is not as if a retail supplier will innovate by creating a more efficient electron.

The only way in which these resellers can innovate is through finding newer and more crafty ways to engage in price discrimination. This is consistent with the arguments brought by Simshauser,[37] who argues that retailers are highly sophisticated and segment the demand curve into multiple segments for price discrimination. And, because it is costless for retailers to post multiple offers each day, across a range of different prices and contract terms, they can segment consumer populations by degrees of information asymmetry. Here, we find that many CRES suppliers post multiple offers each day, across a range of prices, filing both competitive and uncompetitive offers alike, for the purpose of segmenting their customer populations. For a CRES supplier, filing competitive offers for well-informed customers and exploitative offers for others only has upside and no downside, provided the retailers do not engage in illegal activity, although many have. To date, however, it is not illegal to file and sell an over-priced retail energy contract.

6 | CONCLUSION

The grand policy experiment of deregulation, or restructuring, has important implications for critical infrastructure. This paper has motivated a policy discussion regarding the retail electricity sector, and similar important policy arguments can be made for other highly regulated and restructured critical infrastructure sectors. The analyses presented in this paper demonstrate that the method of deregulation that has been used in retail energy markets falls significantly short of what can be considered a competitive market that improves social welfare. We conduct a study of every residential retail supply offer in Ohio over a 9-year period across all service territories and find that most retail energy supply offers are considerably more expensive than even the utility's default service. We find that prices have not converged toward wholesale energy prices, and that there is persistence of considerable price heterogeneity in violation of the Law of One Price. We find that even well-informed consumers who engage frequently with the market will frequently have trouble in obtaining welfare-improving retail energy prices relative to the utility's default service.

We also find some evidence of price signaling, such that retail energy suppliers price not off of the wholesale market but rather price based upon the utility's default service. But, we only find this for a segment of the market, and find that many suppliers price well above the default service rate, with many retail contracts uninfluenced by the default service price signal. We disagree with the policy argument that the utility's default service, or SSO, is distortionary, and support the argument provided by Tschamler,[40] who argued that the SSO plays an important role in providing a social backstop, or safety net, against market abuses. We do not advocate for the elimination of the SSO.

Deregulation and its policy implementation have played an important role in many critical infrastructure sectors over the past 40 years. Considerable expense and effort have been devoted to its study, market

††††††See PUCO Docket, Case No. 22-0128-EL-UNC.
‡‡‡‡‡‡See PUCO Docket, Case No. 22-0583-GE-UNC.
§§§§§§See PUCO Docket, Case No. 22-0267-GE-COI.
*******See PUCO Docket, Case No. 23-0601-EL-UNC.
†††††††See PUCO Docket, Case No. No. 22-441-GE-COI.

design, and redesign. Considerable volumes of research and government publications have attempted to present deregulated markets as efficient, and welfare-improving. However, many of those studies or analyses evaluate wholesale market dynamics and neglect an evaluation from the standpoint of the end consumer. We argue that all of that effort and expense are for naught if the end consumers do not realize or observe those efficiencies. The ultimate aim of deregulation is neither competition nor efficiency, but rather improved social welfare. If the end result is that the consumers see larger markups, inaccessible savings, and commonplace unscrupulous retail sales practices, this grand policy experiment may need further revision.

ACKNOWLEDGMENTS

The authors are grateful to the following individuals for their help, comments, and research support that shaped or influenced this project: Javier Livio, Blain Morin, Grace Koenig, Zejun Li, Marilyn Roberts, and Scott Scribner. The authors are incredibly grateful for the helpful comments and feedback obtained by participants at the 2022 International Association for Energy Economics meetings and the panel formed on Price Formation in Retail Electricity Markets, and especially to Derek Olmstead, David Brown, and James Conville. The authors also thank the supportive staff at the Alfred P. Sloan Foundation for their support for this research, especially to Evan Michelson and Jessica Klynsma. Any conclusions, statements, errors, or omissions are solely those of the authors.

DATA AVAILABILITY STATEMENT

All data used in the analyses contained within this study come from publicly available sources.

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How to cite this article: Dormady, Noah, William Welch, Yufan Ji, Stephanie Pedron, Abdollah Shafieezadeh, Alberto Lamadrid, Matthew Hoyt, and Samantha Fox. 2025. "Efficiency and consumer welfare under retail electricity deregulation: Analysis of Ohio's retail choice markets." *Journal of Critical Infrastructure Policy* 6: e12031. https://doi.org/10.1002/jci3.12031