Online Appendix

"The Long-Run Dynamics of Electricity Demand: Evidence from Municipal Aggregation"

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1 *Municipal Aggregation Materials*

After the proposed aggregation program has been registered with the state, the municipality must hold a referendum. The wording of the referendum question is specified in the Illinois Power Agency Act:[1]

> The election authority must submit the question in substantially the following form:
>
> Shall the (municipality, township, or county in which the question is being voted upon) have the authority to arrange for the supply of electricity for its residential and small commercial retail customers who have not opted out of such program?
>
> The election authority must record the votes as "Yes" or "No".

Figure A.1 displays an example of a letter sent to residents of a community following the passage of an aggregation referendum and selection of a new aggregation supplier. The letter informs residents about their new supply price for electricity, and lets them know that they will have an opportunity to opt out of aggregation. Figure A.2 displays an example of the opt-out card that a customer must fill out and mail if they wish to retain their current electricity supplier.

Figures A.3 and A.4 display the front and back page of a typical electricity bill for a customer residing in ComEd's service territory. If a customer switches suppliers, e.g., her community adopts aggregation and she does not opt out, then the Electricity Supply Charge rate (see Figure A.4) will change. Otherwise her bill will remain the same.

2 *Data Appendix*

Consistent Usage Data

In the usage data provided by ComEd, several communities change definitions over time, moving customers from one community to another or creating a new community. These changes appears as large, discrete jumps in our community-level aggregate usage data. To eliminate this noise, we apply two filters to search for large structural breaks. For each community, we run 89 separate regressions of log usage on month-of-year indicators and a structural break indicator, where we

[1] From 20 ILCS 3855/1-92, Text of Section from P.A. 98-404. Available from http://www.ilga.gov/legislation/ilcs/fulltext.asp?DocName=002038550K1-92.

start the structural break indicator at each month in the sample. We then compare the maximum R-squared to the minimum R-squared among a community's set of regressions. If this difference exceeds 0.5, then the community is dropped from the sample.

For the second filter, we run a series of similar regressions with the addition of a linear time trend. For this filter, we drop any communities for which the explanatory power of the break increases the R-squared by more than 0.2.

Together, these two filters remove 79 communities from our initial sample of 887 service territories. We remove an additional 29 communities from our sample because they were missing data and/or we could not confidently assign them to our treatment or control groups. Finally, we also drop 11 communities that passed a referendum approving aggregation but never implemented the program, leaving us with 768 (= 887 - 79 - 29 - 11) communities in our final sample.

One concern with the two filters that we applied is that we may eliminate actual structural breaks arising from municipal aggregation. However, the communities that were removed in this fashion were primarily small communities that did not implement aggregation.

Other Components of the Electricity Bill

All fixed fees and remaining usage rates are nearly identical across the aggregation and non-aggregation communities in our sample. The average fixed fee for customers residing in ComEd service territories during our sample period is $12.52 per month. We ignore the fixed fees in our analysis, because they do not vary across communities and because our independent variable is the difference in the (log) marginal price between aggregation and non-aggregation communities. In rare instances the aggregation supplier charged an additional fixed fee, but these scenarios were short-lived. Municipal tax rates do vary across communities, but the variation is small and they rarely change over time. For our analysis, we use the median tax rate across ComEd communities (0.557 cents/kWh). The price variable in our estimating equations is equal to the aggregation supply rate plus all other usage rates if the community has implemented aggregation; otherwise, it is equal to the ComEd supply rate plus all other usage rates.

Sources for Aggregation Rates

This section summarizes the data sources used to verify the rates obtained by aggregation communities. The primary data source is Plug In Illinois. If information was unavailable from Plug In Illinois, we tried to retrieve it from websites of the participating communities or from FOIA requests made to the local governments.

Plug In Illinois The website https://pluginillinois.org/MunicipalAggregationList.aspx lists the current state of aggregation programs in Illinois. If a community is currently on an aggregation plan, the rate and the end of the contract are listed. Repeated snapshots of the website were used to track the rates over time. For many of the communities, Plug In Illinois provides a link to access the opt-out letter and a link to the terms and conditions of service.

Opt-Out Letter The opt-out letter is sent to all households following passage of the referendum. The letter confirms the aggregation program and provides them with an opportunity to opt out and remain with ComEd. The letter also includes the aggregation rate and the relevant time period.

Terms and Conditions of Service The terms and conditions are sent to households that do not opt out of the aggregation program. The terms and conditions are an agreement between a household and the alternative retail electric supplier, and they indicate the aggregation rate and the relevant time period.

Master Agreement The master agreement is the contract between the alternative retail electric supplier and the local government. The agreement indicates the term of the agreement and the agreed-upon rate. We obtained these through FOIA requests.

3 *Difference-in-Differences Estimates without Matching*

In this section, we describe how we estimate the effect of implementing aggregation on electricity prices and usage using a standard difference-in-differences model with no matching. Our estimating equation is given by

$$Y_{cmy} = \sum_{\tau=-24,\tau\neq-1}^{24} \beta_\tau A_{c\tau} + \beta_{25} A_{c,25} + \beta_{-25} A_{c,-25} + \alpha_{cm} + \alpha_{my} + \varepsilon_{cmy}, \tag{A.1}$$

where Y_{cmy} is either the natural logarithm of the monthly price or the natural logarithm of total monthly electricity use in community c in calendar month m and year y. The variable $A_{c\tau}$ is an indicator equal to 1 if, as of month m and year y, community c passed an aggregation referendum τ months ago. The month before the referendum ($\tau = -1$) is the omitted category. The main parameter of interest is β_τ.

To ensure that β_τ reflects changes relative to the omitted category, we include indicators for aggregation having been passed 25 or more months ago ($A_{c,25}$) and for aggregation being passed 25 or more months in the future ($A_{c,-25}$). We also include month-by-year (α_{my}) and community-by-month (α_{cm}) fixed effects and cluster standard errors at the community level. We discuss the robustness of our estimates to different sets of fixed effects below.

We also estimate a second, more parametric specification that assesses the effect by six-month periods and uses the entire two years prior to the referendum as the reference period:

$$\begin{aligned} Y_{cmy} = \gamma_1 A_{c,0 \text{ to } 6} + \gamma_2 A_{c,7 \text{ to } 12} + \gamma_3 A_{c,13 \text{ to } 18} + \gamma_4 A_{c,19 \text{ to } 24} \\ + \beta_{25} A_{c,25} + \beta_{-25} A_{c,-25} + \alpha_{cm} + \alpha_{my} + \varepsilon_{cmy}. \end{aligned} \tag{A.2}$$

In this specification, $A_{c,0 \text{ to } 6}$ is an indicator variable equal to 1 if the community passed aggregation in the past 6 months and 0 otherwise. Similarly, $A_{c,7 \text{ to } 12}$ is an indicator equal to 1 if the community passed aggregation between 7 and 12 months ago, and so on. The other variables are defined as in equation (A.1).

One could estimate the effect of implementing aggregation by comparing communities that implemented aggregation to those that did not implement aggregation. However, the latter may not serve as an adequate counterfactual for the former without correcting for systematic differences via matching, as we do in the main text. We therefore restrict our estimation sample here to communities that implemented aggregation.[2] Our main identifying assumption is that, conditional on the included fixed effects, the timing of aggregation adoption is exogenous with respect to electricity use.

Figure A.10 presents the change in electricity prices following aggregation, in logs, as estimated by equation (A.1). Similar to our matching results, prices do not drop immediately following the referendum because it takes time for communities to switch to a new supplier. Unlike the matching estimator, the pre-period price change is not exactly equal to zero in the event-study difference-in-difference. Although treatment and control communities face identical prices in the pre-period in *calendar time*, they do not face identical prices in *event-study time* because ComEd's prices fluctuate month-to-month. This distinction does not matter for the matching estimator, which creates counterfactuals separately for each treated community. The second vertical dashed line in Figure A.10 shows the point at which half of all communities have implemented aggregation (4 months after passing the referendum). Prices continue to drop as more communities switch and then eventually stabilize. Within 8 months of passing the referendum, the average electricity price has decreased by more than 0.3 log points (26 percent) in aggregation communities relative to the control group.

Figure A.11 shows the corresponding estimates for electricity usage. Prior the referendum, the difference in usage between aggregation and the control communities is statistically indistinguishable from zero. Usage in aggregation communities then begins to increase following the referendum. By the end of the first year, usage in aggregation communities is about 0.1 log points (9.5 percent) higher relative to the counterfactual.

[2] We also estimated a specification that uses all non-aggregation communities as controls. Those estimates are similar to the ones we present here, although the coefficients are much less stable.

Table A.6 shows the estimated impact of aggregation on the log of the electricity price in these communities 0–6, 7–12, 13–18, and 19–24 months after implementation, as estimated by equation (A.2). The results consistently show large and significant price drops, and are robust to including different fixed effects. Our preferred specification is presented in Column 4 and includes community-by-month and month-by-year fixed effects. This specification estimates that electricity prices fell by 0.1 log points in the first six months, and eventually stabilizes around 0.3 log points by the end of the first year.

Table A.7 shows the estimated change in usage as estimated by equation (A.2) for the sample of communities that implemented aggregation. Our preferred specification, presented in Column 4, estimates that electricity usage is 0.048 log points higher in the first 6 months following the referendum, and this increases to 0.114 log points within one year.

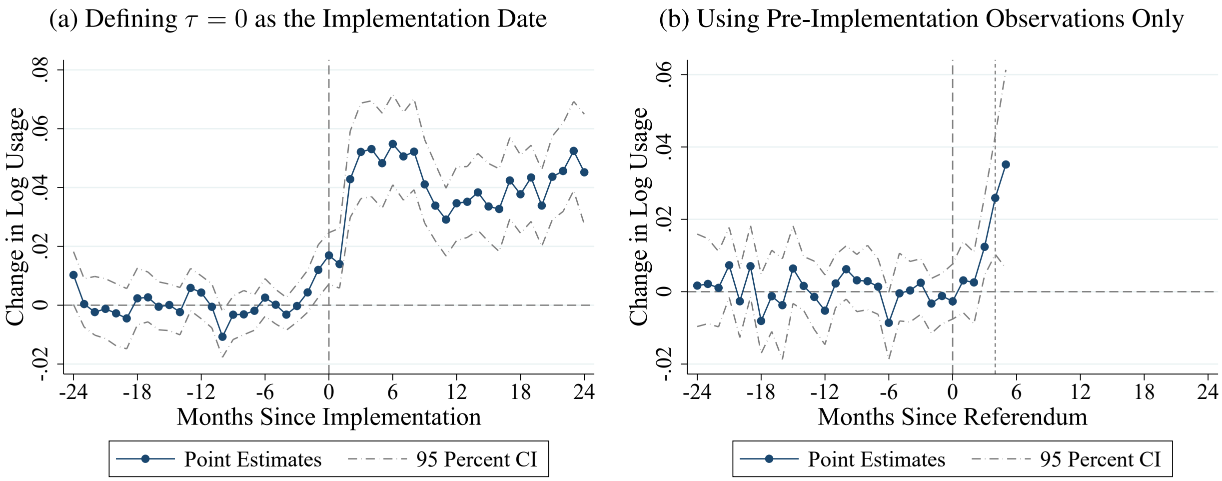
Finally, Figure A.12 shows the elasticities implied by the usage and price results. Similar to the main text, we regress the predicted aggregation-driven log change in a community's electricity usage on the change in log prices. To account for uncertainty in the price and usage estimates, we cluster bootstrap the confidence intervals using 1000 draws. The implied elasticity ranges from -0.33 7–12 months after passage of aggregation to -0.45 two and a half years after passage. The differences in the magnitude between these and our matching estimates may be due to the fact that they reflect a slightly different mix of communities and a different combination of short-run and longer-run responses.

4 Anticipation Effects

Forward-looking individuals should respond to policies prior to their implementation if those policies can be anticipated and if there is a benefit of responding in advance. For example, prior studies have documented that expectations of future policies and prices matter when purchasing durables such as cars or houses or when making human capital investments (e.g., Poterba, 1984; Ryoo and Rosen, 2004; Allcott and Wozny, 2014; Myers, 2016). The effect of aggregation on electricity usage is a good setting for detecting anticipation effects: the implementation of aggregation was widely announced months ahead of time, and electricity usage depends on durable goods like air conditioners, water heaters, and dishwashers, as well as on consumer habits and knowledge. Though a price decrease is unlikely to cause an immediate spike in purchases of energy-inefficient appliances, depreciated durable goods are continuously being replaced within a population, and the efficiency of the replacement should depend, at the margin, on the price of electricity.

Both dynamic specifications reported in Table 3 find a small but significant anticipation response in the six months prior to a price change. To further validate this result, we re-estimate the reduced-form specification given in equation (5), setting $t = 0$ to be the date that aggregation was *implemented* (which corresponds to the date of the price change) rather than the date of the aggre-

Figure 1: Anticipation Effects of Implementing Aggregation on Log Usage



Notes: The figure displays estimates of the anticipation effects of implementing aggregation. In Panel (a), the vertical dashed line corresponds to the month when aggregation was implemented. In Panel (b), the vertical dashed line corresponds to the month when aggregation was passed, and the short-dashed line indicates the median implementation period. Confidence intervals are constructed via subsampling.

gation *referendum*. The results are shown in panel (a) of Figure 1. The price difference between aggregation communities and their matched controls is zero prior to implementation. However, usage begins increasing three months prior to the price change.

To explicitly isolate the anticipation effect, Panel (b) of Figure 1 displays estimates of changes in electricity usage relative to the *referendum* date, using only pre-implementation data. Electricity usage increases steadily and significantly 3-5 months after the referendum despite the fact that prices have not yet changed for the observations in this sample. Specifically, usage is 0.012 log points higher 3 months after the referendum and 0.035 log points higher 5 months after the referendum, confirming the existence of non-trivial anticipation effects in our sample. We do not observe any significant change in usage prior the referendum.

Together, these results suggest that the referendum and/or the subsequent price change announcement alerted consumers to the impending price decrease and caused them to increase their usage, perhaps by placing less weight on energy efficiency when replacing old appliances or by changing their electricity usage habits (relative to their control counterparts). Alternatively, it is possible that customers were confused about the timing of the price change, although we note that mailers were sent to all residents informing them of the exact month of the price change. More generally, while our estimates are consistent with a standard forward-looking model of rational consumers, they are also consistent with confusion and other behavioral mechanisms. Regardless of the precise mechanism, to the extent that other policies are implemented in a similar manner, they are likely to generate pre-implementation effects similar to those we find here.

5 *Demographic Characteristics*

Illinois versus the United States

Illinois is similar to the U.S. as a whole along several dimensions related to electricity consumption. Using daily station-level weather data from NOAA, we calculate that the average number of population-weighted heating degree days between 1965–2010 in Illinois (U.S.) is 5,997 (5,115), while the average number of population-weighted cooling degree days is 881 (1,086). Considering that the state-level standard deviations for these two measures are approximately 2,100 and 746, Illinois provides a close proxy for the average U.S. temperature patterns. Likewise, from 2000 to 2015, the difference between the average annual electricity price in Illinois and the U.S. as a whole was -0.4 cents per kWh, which is only about four percent of the U.S. mean (U.S. Energy Information Administration, 2017).

From 2011 to 2015, Illinois had an average per capita income of $30,494 (in 2015 dollars), which is very close to the U.S. average of $28,930. Similarly, the Illinois employment rate was 65.6 percent, while the U.S. employment rate was 63.6 percent (United States Census Bureau, 2016). The 2010 demographic characteristics of Illinois are also comparable to the U.S. average: 14.5 percent of the Illinois population is black (versus 12.6 percent for the U.S.), 12.5 percent is over the age of 65 (versus 13 percent for the U.S.), and 24.4 percent is under the age of 18 (versus 24 percent in the U.S.).

Elasticities by Demographic Characteristics

Next, we investigate how much variation in the reduced-form price elasticity can be explained by demographic characteristics. Doing so helps us understand both the distributional effects of policies that affect electricity prices and the generalizability of our results. For this exercise, we regress the log net usage change at time t on the contemporaneous log price change and add interactions between the log price change and indicator variables for whether or not a community is in the top half of the distribution for x^j, a characteristic of interest:

$$\widehat{\tau}_{it} = \beta_g \cdot \Delta \ln p_{it} + \sum_{j=1}^{J} (\beta_j \cdot \Delta \ln p_{it} \cdot \mathbf{1}[x_i^j > median(x^j))] + \eta_{it}.$$

The indicator $\mathbf{1}[x_i^j > median(x^j)]$ is equal to 1 if the value of the (time-invariant) variable x^j for community i is above the median of the distribution and 0 otherwise. We estimate this regression using $J = 8$ different characteristics obtained from the ACS, and report our results in Figures A.13 and A.14. Because the estimation is done jointly, the displayed elasticities for any given characteristic control for the other characteristics.

Figure A.13 reports heterogeneity results for variables related to the housing stock. Estimates that are statistically different from each other (at the 10 percent level) are indicated with a marker. Communities with newer homes (as measured by "year built") have a more elastic demand response, conditional on the other characteristics. This difference could arise because newer homes are more likely to have technology such as programmable thermostats, which make it easier for consumers to control electricity consumption.

Figure A.14 reports heterogeneity results for socioeconomic characteristics. Surprisingly, age and race appear to matter for the elasticity of demand more than economic variables such as income and education. Younger communities have a more elastic response, as do communities with a greater percentage of white people. By contrast, our elasticity estimates are relatively stable across economic characteristics.

6 Framework for Consumption Dynamics

Summary

Residential electricity usage is unlikely to adjust immediately to price changes. It takes time to change habits, such as turning off the lights or turning down the air conditioning when away from home. Usage also depends on the energy efficiency of durables such as dishwashers, dryers, and air conditioners, which are purchased infrequently and are continuously replaced within a population. Finally, some consumers may need time to learn that the electricity price has changed, especially if the benefit of tracking price changes is small relative to the cost of paying attention.

The presence of such adjustment costs suggests that the long-run response to a price change will exceed the short-run response. Moreover, if consumers are forward-looking, they may respond in anticipation of future price changes. Here, we present a simple framework demonstrating that our empirical approach in Section V is consistent with a standard rational model of a forward-looking consumer.

We employ the habit model of Becker et al. (1994), and provide a full derivation of these results at the end of this appendix. Utility in each period depends on y_t, the consumption of electricity in that period, and on y_{t-1}, the consumption of electricity in the previous period.[3] The consumer's problem is:

$$\max_{y_t, x_t} \sum_{t=1}^{\infty} R^{t-1} U\left(y_t, y_{t-1}, x_t\right),$$

where y_0 is given, $R < 1$ is the consumer's discount factor, and x_t represents consumption of a composite good that is taken as numeraire. The consumer's budget constraint is

[3] Similarly, one could allow utility in each period to depend on a "stock" of appliances (Filippini et al., 2018). The resulting model will exhibit dynamics similar to what we present here.

$$W_0 = \sum_{t=1}^{\infty} R^{t-1} \left(x_t + p_t y_t \right),$$

where W_0 is the present value of wealth, and p_t is the price of the electricity.

We assume that consumers are forward-looking, and, for expositional purposes, we assume they have perfect foresight. Finally, to illustrate the dynamics that can arise in our setting, we assume utility is quadratic.[4] Under these assumptions, the demand equation is:

$$y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t+1} + \alpha_3 p_t, \tag{A.3}$$

where the coefficients in equation (A.3) depend on the parameters of the quadratic utility function. The "adjustment cost" model frequently estimated in the energy demand literature corresponds to the special case where consumers are myopic, in which case the demand equation simplifies to:

$$y_t = \theta_1 y_{t-1} + \theta_2 p_t. \tag{A.4}$$

In the forward-looking model (A.3), consumers adjust their consumption in anticipation of future price changes, which are implicitly captured by y_{t+1}. They do not do so in the myopic adjustment model (A.4). Prior studies have noted that one can therefore test the myopic model by testing whether demand responds to future prices (Becker et al., 1994; Gruber and Köszegi, 2001).

One can equivalently express demand as a function of all past and future prices by solving the second-order difference equation (A.3):

$$y_t = \sum_{s=0}^{t-1} \delta_{t-s} p_{t-s} + \sum_{s=1}^{\infty} \delta_{t+s} p_{t+s}. \tag{A.5}$$

The effect of a price change on consumption will depend on whether the change was anticipated and on how long consumers expect the price change to last. Given estimates of equation (A.5), the long-run effect of a permanent change in price, p^*, on consumption can then be calculated as

$$\frac{dy}{dp^*} = \sum_{s=0}^{t-1} \widehat{\delta}_{t-s} + \sum_{s=1}^{\infty} \widehat{\delta}_{t+s}. \tag{A.6}$$

An appealing feature of equation (A.5) is that it is more flexible than equation (A.3). For example, it will generate a valid estimate of dy/dp^* even if consumers do not discount the future exponentially. This non-parametric specification is rarely estimated, however, because most studies do not have data panels of sufficient length.

[4] Alternatively, to analyze dynamics near a steady state, one could allow utility to be general and take a linear approximation to the first-order conditions, which would yield identical equations.

Derivations

As shown in Becker et al. (1994), the effect of a price change on consumption at a particular point in time depends on whether or not the change was anticipated; when the change occurred; and whether the change is temporary or permanent. This can be shown by solving the second-order difference equation (A.3) to obtain:

$$y_t = K_1 \sum_{s=1}^{\infty} (\lambda_1)^{-s} \alpha_3 p_{t+s-1} + K_2 \sum_{s=0}^{t-1} (\lambda_2)^{s} \alpha_3 p_{t-s-1} + (\lambda_2)^t \left(y_0 - K_1 \sum_{s=1}^{\infty} (\lambda_1)^{-s} \alpha_3 p_{s-1} \right) \tag{A.7}$$

where

$$\begin{aligned} K_1 &= \frac{\lambda_1}{\alpha_2 (\lambda_1 - \lambda_2)} \\ K_2 &= \frac{\lambda_2}{\alpha_2 (\lambda_1 - \lambda_2)} \end{aligned}$$

with roots

$$\begin{aligned} \lambda_1 &= \frac{2\alpha_1}{1 - \sqrt{1 - 4\alpha_1\alpha_2}} > 1 \\ \lambda_2 &= \frac{2\alpha_1}{1 + \sqrt{1 - 4\alpha_1\alpha_2}} < 1 \end{aligned}$$

See Reif (2019) for additional details.

Equation (A.7) shows that consumption in period t is a function of all future prices, all past prices, and the initial condition y_0. In long-run equilibrium ($t \to \infty$), the third term in equation (A.7) becomes zero, so that consumption no longer depends on the initial condition, y_0. The long-run effect of a permanent change in price in all periods is

$$\frac{dy}{dp^*} = K_1 \sum_{s=1}^{\infty} (\lambda_1)^{-s} \alpha_3 + K_2 \sum_{s=0}^{\infty} (\lambda_2)^{s} \alpha_3$$

which corresponds to equation (A.6) as $t \to \infty$.

It is straightforward to show that the solution to the first-order difference equation (A.4), the myopic "adjustment cost" model, depends only on past prices, and not on future prices.

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Appendix Tables

Table A.1: Number of Nearest Neighbors and Reduced-Form Estimates

(a) 5 Nearest Neighbors

	Log Usage	Log Price	Elasticity	Usage Obs.	Price Obs.
1-6 Months	0.014***	-0.098***	-0.094***	1692	1692
	(0.003)	(0.003)	(0.019)		
7-12 Months	0.050***	-0.249***	-0.155***	1668	1668
	(0.007)	(0.007)	(0.020)		
13-18 Months	0.043***	-0.147***	-0.228***	1516	1515
	(0.005)	(0.002)	(0.027)		
19-24 Months	0.039***	-0.132***	-0.272***	1155	1155
	(0.006)	(0.003)	(0.043)		
25-30 Months	0.043***	-0.120***	-0.275***	606	604
	(0.007)	(0.004)	(0.039)		

(b) 1 Nearest Neighbor

	Log Usage	Log Price	Elasticity	Usage Obs.	Price Obs.
1-6 Months	0.016***	-0.098***	-0.098***	1692	1692
	(0.004)	(0.003)	(0.022)		
7-12 Months	0.051***	-0.249***	-0.159***	1668	1668
	(0.007)	(0.007)	(0.020)		
13-18 Months	0.047***	-0.147***	-0.248***	1516	1515
	(0.006)	(0.002)	(0.030)		
19-24 Months	0.044***	-0.132***	-0.301***	1155	1155
	(0.007)	(0.003)	(0.049)		
25-30 Months	0.047***	-0.120***	-0.306***	606	604
	(0.008)	(0.004)	(0.046)		

(c) 10 Nearest Neighbors

	Log Usage	Log Price	Elasticity	Usage Obs.	Price Obs.
1-6 Months	0.015***	-0.098***	-0.099***	1692	1692
	(0.003)	(0.003)	(0.019)		
7-12 Months	0.051***	-0.249***	-0.162***	1668	1668
	(0.007)	(0.007)	(0.020)		
13-18 Months	0.044***	-0.147***	-0.228***	1516	1515
	(0.006)	(0.002)	(0.027)		
19-24 Months	0.040***	-0.132***	-0.283***	1155	1155
	(0.006)	(0.003)	(0.044)		
25-30 Months	0.044***	-0.120***	-0.283***	606	604
	(0.007)	(0.004)	(0.040)		

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Estimates are constructed by a nearest-neighbor matching approach where each aggregation community is matched to non-aggregation communities with the most similar usage in 2008 and 2009. The number of price observations corresponds to the number of observations for each elasticity estimate, as we always observe usage where we observe a price change. Standard errors are in parentheses. Standard error are determined by subsampling.

Table A.2: Comparison of Tuning Parameters for Subsampling

R	B_1	Type	Months 1-6	Months 7-12	Months 13-18	Months 19-24	Months 25-30
		Point Estimate	-0.0939	-0.1550	-0.2280	-0.2723	-0.2748
1	17	Standard Error	0.0208	0.0221	0.0283	0.0476	0.0444
2	34	Standard Error	0.0197	0.0204	0.0275	0.0471	0.0430
3	51	Standard Error	0.0190	0.0199	0.0265	0.0430	0.0386
5	85	Standard Error	0.0176	0.0185	0.0242	0.0388	0.0352
7	119	Standard Error	0.0169	0.0158	0.0217	0.0364	0.0334

Results from our bi-annual elasticity estimates are reported above. The first row reports the point estimates. The remaining rows report the standard errors calculated via subsampling with different values of the tuning parameter, R, and the corresponding subsample size in terms of treated communities, B_1. Confidence intervals throughout the paper are calculated with $R = 3$.

Table A.3: Characteristics of Aggregation, Non-Aggregation, and Matched Control Communities

	(1) Aggregation Mean	(2) Non-Aggregation Mean	(3) p-value of Difference (2)-(1)	(4) Matched Controls Mean	(5) p-value of Difference (4)-(1)
Per Capita Electricity Usage in 2010, kWh	4,893	5,078	0.790	4,862	0.964
Total Population (Log)	8.63	7.20	<0.001	8.43	0.135
Percent Black	4.92	5.41	0.663	8.26	0.038
Percent White	86.54	89.06	0.055	83.49	0.087
Median Income	71,848	68,371	0.119	71,437	0.876
Median Age	38.63	40.80	<0.001	38.90	0.625
Total Housing Units (log)	7.69	6.27	<0.001	7.45	0.083
Median Year Built	1,969	1,965	0.006	1,972	0.023
Median Housing Value	264,723	222,617	0.001	250,355	0.310
Percent with High School Education	29.80	36.29	<0.001	32.75	0.005
Percent with Some College Education	29.73	31.39	0.008	30.53	0.227
Percent with Bachelor Degree	18.32	14.31	<0.001	16.71	0.087
Percent with Graduate Degree	11.22	7.43	<0.001	9.01	0.007
Latitude	41.91	41.67	<0.001	41.80	0.005
Longitude	-88.41	-88.53	0.025	-88.20	<0.001
Number of Unique Communities	286	385		271	

Mean characteristics for aggregation communities, non-aggregation communities, and matched control (non-aggregation) communities are reported. Electricity usage data come from ComEd. All other characteristics are from the 2005-2009 American Community Survey (ACS). We obtained non-ambiguous ACS matches for 286 out of 289 aggregation communities and 385 out of 479 non-aggregation communities. The number of observations in column (1) is smaller for median year built (285). The number of observations in column (2) is smaller for median housing value (383). Estimates in columns (4) and (5) are weighted by the number of times the control community is a match for a treated community.

Table A.4: Matching Estimates of the Effect of Aggregation on Usage and Prices, Monthly

	Log Usage	Log Price	Elasticity	Usage Obs.	Price Obs.
Month 3	0.014***	-0.063***	-0.061**	286	286
	(0.005)	(0.007)	(0.037)		
Month 4	0.020***	-0.114***	-0.081***	278	278
	(0.006)	(0.007)	(0.032)		
Month 5	0.020***	-0.187***	-0.095***	278	278
	(0.006)	(0.007)	(0.028)		
Month 6	0.025***	-0.224***	-0.107***	278	278
	(0.007)	(0.005)	(0.027)		
Month 7	0.032***	-0.240***	-0.094***	278	278
	(0.008)	(0.010)	(0.025)		
Month 8	0.041***	-0.262***	-0.114***	278	278
	(0.008)	(0.008)	(0.020)		
Month 9	0.057***	-0.257***	-0.175***	278	278
	(0.008)	(0.007)	(0.024)		
Month 10	0.055***	-0.243***	-0.182***	278	278
	(0.009)	(0.007)	(0.028)		
Month 11	0.059***	-0.272***	-0.170***	278	278
	(0.008)	(0.008)	(0.023)		
Month 12	0.054***	-0.222***	-0.227***	278	278
	(0.009)	(0.006)	(0.032)		
Month 13	0.057***	-0.222***	-0.236***	278	278
	(0.009)	(0.006)	(0.033)		
Month 14	0.045***	-0.228***	-0.161***	278	277
	(0.008)	(0.005)	(0.026)		
Month 15	0.037***	-0.050***	-0.418***	240	240
	(0.007)	(0.003)	(0.097)		
Month 16	0.038***	-0.110***	-0.321***	240	240
	(0.007)	(0.002)	(0.061)		
Month 17	0.045***	-0.119***	-0.361***	240	240
	(0.007)	(0.002)	(0.058)		
Month 18	0.033***	-0.128***	-0.220***	240	240
	(0.008)	(0.003)	(0.058)		
Month 19	0.036***	-0.140***	-0.232***	240	240
	(0.008)	(0.004)	(0.053)		
Month 20	0.036***	-0.135***	-0.248***	183	183
	(0.008)	(0.004)	(0.058)		
Month 21	0.047***	-0.132***	-0.325***	183	183
	(0.008)	(0.003)	(0.055)		
Month 22	0.035***	-0.133***	-0.246***	183	183
	(0.008)	(0.004)	(0.055)		
Month 23	0.040***	-0.125***	-0.309***	183	183
	(0.007)	(0.003)	(0.057)		
Month 24	0.040***	-0.125***	-0.308***	183	183
	(0.007)	(0.003)	(0.056)		
Month 25	0.039***	-0.121***	-0.327***	183	182
	(0.007)	(0.003)	(0.058)		
Month 26	0.040***	-0.097***	-0.290***	183	182
	(0.008)	(0.005)	(0.062)		
Month 27	0.046***	-0.166***	-0.236***	183	183
	(0.008)	(0.006)	(0.038)		

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Estimates are constructed by a nearest-neighbor matching approach where each aggregation community is matched to the five non-aggregation communities with the most similar usage in 2008 and 2009. Months 0–2 are not shown as no aggregation community switches suppliers that quickly following a referenda, resulting in price changes that are identically zero and undefined reduced-form elasticities. The number of price observations corresponds to the number of observations for each elasticity estimate, as we always observe usage where we observe a price change. Standard errors are in parentheses. Significance is determined by subsampling to construct confidence intervals.

Table A.5: Matching Estimates of the Effect of Aggregation on Usage and Prices, Yearly

Post-Referendum Period	Log Usage	Log Price	Elasticity	Usage Obs.	Price Obs.
1-12 Months	0.032***	-0.173***	-0.140***	3360	3360
	(0.005)	(0.004)	(0.018)		
13-24 Months	0.041***	-0.141***	-0.243***	2671	2670
	(0.005)	(0.002)	(0.028)		
25-36 Months	0.046***	-0.108***	-0.285***	720	718
	(0.008)	(0.006)	(0.041)		

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Estimates are constructed by a nearest-neighbor matching approach where each aggregation community is matched to the five non-aggregation communities with the most similar usage in 2008 and 2009. The number of price observations corresponds to the number of observations for each elasticity estimate, as we always observe usage where we observe a price change. Standard errors are in parentheses. Significance is determined by subsampling to construct confidence intervals.

Table A.6: Effect of Aggregation on Electricity Prices, Communities that Passed Aggregation

	(1)	(2)	(3)	(4)
0-6 Months Post-Aggregation	-0.119***	-0.100***	-0.123***	-0.101***
	(0.005)	(0.005)	(0.005)	(0.005)
7-12 Months Post-Aggregation	-0.307***	-0.313***	-0.312***	-0.320***
	(0.007)	(0.007)	(0.007)	(0.007)
13-18 Months Post-Aggregation	-0.297***	-0.265***	-0.303***	-0.267***
	(0.008)	(0.009)	(0.008)	(0.010)
19-24 Months Post-Aggregation	-0.283***	-0.285***	-0.285***	-0.287***
	(0.010)	(0.013)	(0.010)	(0.013)
25-30 Months Post-Aggregation	-0.281***	-0.264***	-0.296***	-0.279***
	(0.013)	(0.017)	(0.014)	(0.018)
Community Fixed Effects	X	X		
Month and Year Fixed Effects	X		X	
Month-by-Year Fixed Effects		X		X
Community-by-Month Fixed Effects			X	X
Dep. Var. Mean	2.202	2.202	2.202	2.202
Observations	25,716	25,716	25,716	25,716
Adjusted R-squared	0.793	0.898	0.802	0.907

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard errors (in parentheses) clustered by community. Outcome variable is the log of the per-kWh electricity price.

Table A.7: Effect of Aggregation on Electricity Usage, Communities that Passed Aggregation

	(1)	(2)	(3)	(4)
0-6 Months Post-Aggregation	0.073***	0.059***	0.066***	0.048***
	(0.008)	(0.009)	(0.005)	(0.006)
7-12 Months Post-Aggregation	0.054***	0.095***	0.065***	0.114***
	(0.012)	(0.016)	(0.012)	(0.016)
13-18 Months Post-Aggregation	0.107***	0.140***	0.088***	0.114***
	(0.015)	(0.019)	(0.014)	(0.017)
19-24 Months Post-Aggregation	0.084***	0.073***	0.109***	0.114***
	(0.016)	(0.023)	(0.015)	(0.021)
25-30 Months Post-Aggregation	0.067***	0.139***	0.067***	0.133***
	(0.020)	(0.025)	(0.020)	(0.024)
Community Fixed Effects	X	X		
Month and Year Fixed Effects	X		X	
Month-by-Year Fixed Effects		X		X
Community-by-Month Fixed Effects			X	X
Dep. Var. Mean	14.371	14.371	14.371	14.371
Observations	25,716	25,716	25,716	25,716
Adjusted R-squared	0.991	0.993	0.996	0.998

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard errors (in parentheses) clustered by community. Outcome variable is the log of total electricity usage.

Table A.8: Number of Nearest Neighbors and the Dynamic Elasticity Curve

(a) 5 Nearest Neighbors

Period After Price Change	Non-Parametric	Parametric	Reduced Form
1-6 Months Prior	-0.023**	-0.022***	N/A
	(0.010)	(0.006)	
Contemporaneous	-0.050***	-0.052***	-0.034**
	(0.015)	(0.010)	(0.021)
1-6 Months	-0.083***	-0.087***	-0.069***
	(0.013)	(0.012)	(0.011)
7-12 Months	-0.145***	-0.138***	-0.122***
	(0.018)	(0.017)	(0.017)
13-18 Months	-0.168***	-0.179***	-0.218***
	(0.022)	(0.023)	(0.035)
19-24 Months	-0.209***	-0.212***	-0.260***
	(0.031)	(0.028)	(0.038)

(b) 1 Nearest Neighbor

Period After Price Change	Non-Parametric	Parametric	Reduced Form
1-6 Months Prior	-0.024**	-0.023***	N/A
	(0.012)	(0.007)	
Contemporaneous	-0.043***	-0.056***	-0.010
	(0.018)	(0.012)	(0.025)
1-6 Months	-0.084***	-0.085***	-0.071***
	(0.014)	(0.013)	(0.012)
7-12 Months	-0.135***	-0.131***	-0.115***
	(0.020)	(0.018)	(0.018)
13-18 Months	-0.162***	-0.172***	-0.226***
	(0.023)	(0.024)	(0.040)
19-24 Months	-0.191***	-0.208***	-0.223***
	(0.033)	(0.030)	(0.046)

(c) 10 Nearest Neighbors

Period After Price Change	Non-Parametric	Parametric	Reduced Form
1-6 Months Prior	-0.025***	-0.024***	N/A
	(0.010)	(0.007)	
Contemporaneous	-0.052***	-0.057***	-0.056***
	(0.016)	(0.010)	(0.020)
1-6 Months	-0.086***	-0.092***	-0.071***
	(0.013)	(0.012)	(0.011)
7-12 Months	-0.146***	-0.144***	-0.119***
	(0.019)	(0.018)	(0.016)
13-18 Months	-0.176***	-0.185***	-0.244***
	(0.024)	(0.024)	(0.035)
19-24 Months	-0.211***	-0.219***	-0.253***
	(0.033)	(0.030)	(0.039)

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. The elasticities are interpreted as the cumulative effect of a permanent one-percent price change on current usage. Estimates are constructed from a regression of log usage changes on leads and lags of log price changes. The coefficients are constrained to match a four-parameter model. Changes in log usage and log price are estimated using a nearest-neighbor matching approach where each aggregation community is matched to the five non-aggregation communities with the most similar usage in 2008 and 2009. Standard errors are constructed via subsampling.

Appendix Figures

Figure A.1: Example of an Aggregation Mailing

Kane County
C/O Dynegy Energy Services
1500 Eastport Plaza Dr.
Collinsville, IL 62234

John A. Smith
123 Main St
Anytown, IL 65432

Kane County is pleased to announce that Dynegy Energy Services, LLC ("DES") has been selected as the Supplier for its Municipal Aggregation program. This includes a 24-month program with a fixed price of $**0.06533 per kilowatt hour (kWh)** for the first 12 months (August 2015 to August 2016) and steps down to **$0.06065 per kWh** for the last 12 months (August 2016 to August 2017). DES is an independent seller of power and energy service and is certified as an Alternative Retail Electricity Supplier by the Illinois Commerce Commission (ICC Docket No. 14-0336).

As an eligible residential or small business customer located in unincorporated portions of Kane County, you will be automatically enrolled unless you opt out.

HOW TO OPT-OUT
You need do nothing to receive this new fixed rate. However, if you choose not to participate, simply return the enclosed Opt-Out Card **or call DES at 844-351-7691** by **July 10, 2015.** For more information, visit www.DynegyEnergyServices.com or contact DES Customer Care at 866-694-1262 from 8:00am to 7:00pm Mon- Fri or via email at DESCustCare@Dynegy.com.

There is no enrollment fee, no switching fee, and no early termination fee. This is a firm, fixed all-inclusive rate guaranteed until **August 2017**. This program offers automatic enrollment in Traditionally-sourced Power, but you have an option of purchasing Renewable Power at a rate of $**0.06766 per kWh** for the first 12 months (August 2015 to August 2016) which steps down to $**0.06327 per kWh** for the last 12 months (August 2016 to August 2017).

ENROLLMENT PROCESS
Once your account is enrolled, you will receive a confirmation letter from ComEd confirming your switch to DES. A sample ComEd notice is attached. Approximately 30 to 45 days after enrollment you will receive your first bill with your new DES price. Please review the enclosed Terms and Conditions for additional information.

Please be advised you also have the option to purchase electricity supply from a Retail Electric Supplier (RES) or from ComEd pursuant to Section 16-103 of the Public Utilities Act. Information about your options can be found at the Illinois Commerce Commission website: www.pluginilllinois.org and www.ComEd.com. You may request a list of all supply options available to you from the Illinois Power Agency.

Sincerely,

See Reverse for Frequently Asked Questions…

Christopher J. Lauzen
Board Chairman
Kane County

Kurt R. Kojzarek
Development Committee Chairman
Kane County

Figure A.2: Example of an Opt-Out Card

PLACE

STAMP

MC SQUARED ENERGY SERVICES, LLC
344 South Poplar Street
Hazleton, PA 18201

___ **Opt-Out by returning this form:** I wish to opt-out of the Village of South Barrington electricity aggregation program and remain with my current provider. By returning this signed form, I will be **excluded** from this opportunity to join with other residents in the electricity aggregation program.

You must mail this form by **June 15, 2012**

Name: ______________________________

Service Address: ______________________________

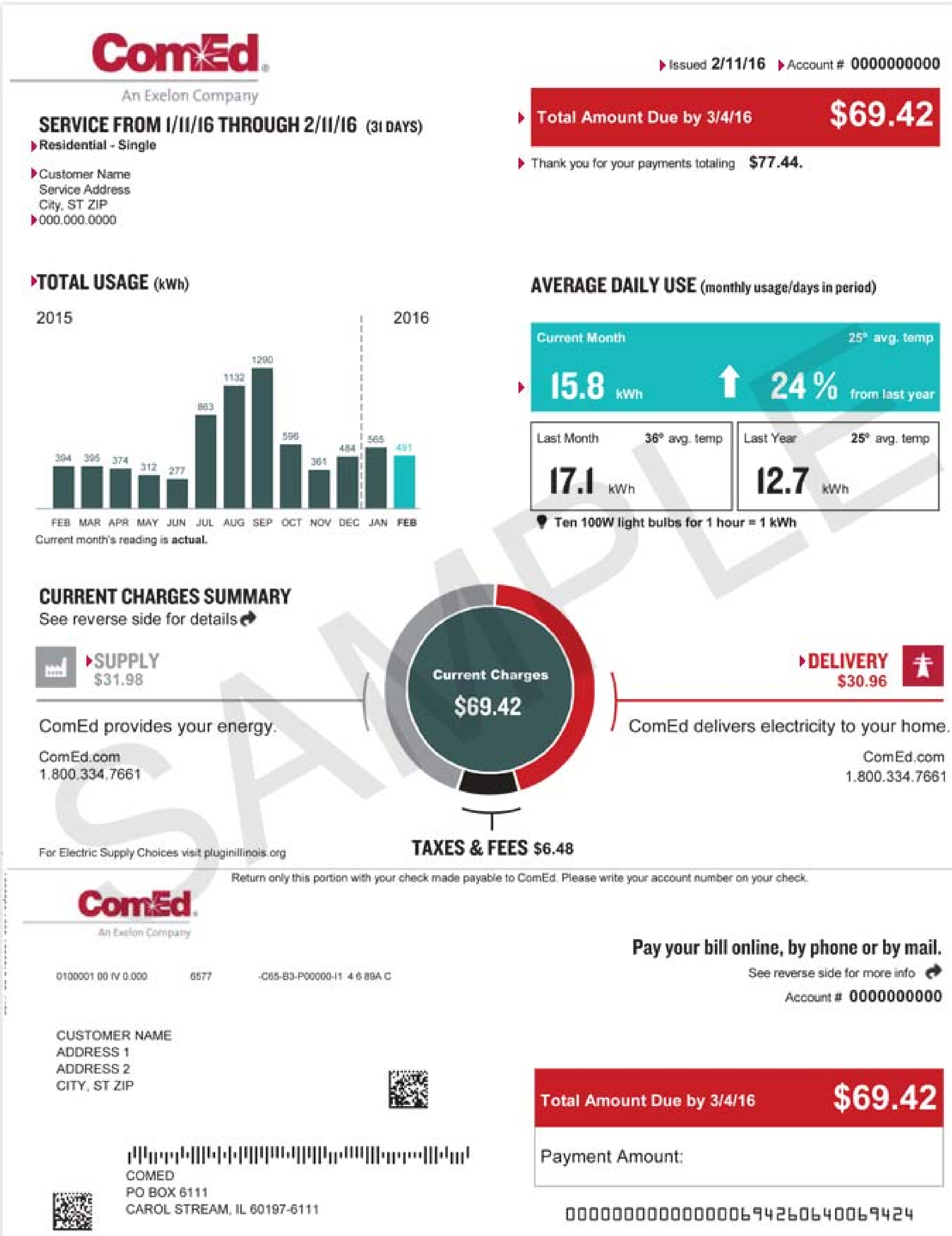
City, State, Zip: ______________________________

Phone: ______________________________

Account Holder's Signature: ______________________ Date: ____________

Rev 1 – 5/17/12

Figure A.3: Example of a ComEd Bill (page 1 of 2)



ComEd
An Exelon Company

SERVICE FROM 1/11/16 THROUGH 2/11/16 (31 DAYS)
Residential - Single

Customer Name
Service Address
City, ST ZIP
000.000.0000

Issued 2/11/16 Account # 0000000000

Total Amount Due by 3/4/16 $69.42

Thank you for your payments totaling $77.44.

TOTAL USAGE (kWh)

2015 | 2016

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
394	395	374	312	277	863	1132	1290	596	361	484	565	491

Current month's reading is actual.

AVERAGE DAILY USE (monthly usage/days in period)

Current Month 25° avg. temp
15.8 kWh 24 % from last year

Last Month 36° avg. temp
17.1 kWh

Last Year 25° avg. temp
12.7 kWh

Ten 100W light bulbs for 1 hour = 1 kWh

SAMPLE

CURRENT CHARGES SUMMARY
See reverse side for details

SUPPLY
$31.98
ComEd provides your energy.
ComEd.com
1.800.334.7661

Current Charges
$69.42

DELIVERY
$30.96
ComEd delivers electricity to your home.
ComEd.com
1.800.334.7661

For Electric Supply Choices visit pluginillinois.org

TAXES & FEES $6.48

Return only this portion with your check made payable to ComEd. Please write your account number on your check.

ComEd
An Exelon Company

0100001 00 IV 0.000 6577 -C65-B3-P00000-I1 4 6 89A C

Pay your bill online, by phone or by mail.
See reverse side for more info
Account # 0000000000

CUSTOMER NAME
ADDRESS 1
ADDRESS 2
CITY, ST ZIP

Total Amount Due by 3/4/16 $69.42

Payment Amount:

COMED
PO BOX 6111
CAROL STREAM, IL 60197-6111

0000000000000006942606400069424

Figure A.4: Example of a ComEd Bill (page 2 of 2)

For Questions, Support, and Outages visit ComEd.com

English	1.800.EDISON1 (1.800.334.7661)
Español	1.800.95.LUCES (1.800.955.8237)
Hearing/Speech Impaired	1.800.572.5789 (TTY)
Federal Video Relay Services (VRS)	Fedvrs.us/session/new

Issued **2/11/16** Account # **0000000000**

Total Amount Due by 3/4/16 $69.42

METER INFORMATION

Read Dates	Meter Number	Load Type	Reading Type	Previous	Present	Difference	Multiplier	Usage
1/11-2/11	000000000	General Service	Total kWh	94278 **Actual**	94769 **Actual**	491	x 1	**491**

CHARGE DETAILS

Residential - Single 1/11/16 - 2/11/16 (31 Days)

SUPPLY **$31.98**

Electricity Supply Charge	491 kWh X 0.05865	$28.80
Transmission Services Charge	491 kWh X 0.01122	$5.51
Purchased Electricity Adjustment		-$2.33

DELIVERY - ComEd **$30.96**

Customer Charge		$10.53
Standard Metering Charge		$4.36
Distribution Facilities Charge	491 kWh X 0.03156	$15.50
IL Electricity Distribution Charge	491 kWh X 0.00116	$0.57

TAXES & FEES **$6.48**

Environmental Cost Recovery Adj	491 kWh X 0.00038	$0.19
Energy Efficiency Programs	491 kWh X 0.00345	$1.69
Franchise Cost	$30.39 X 2.36300%	$0.72
State Tax		$1.62
Municipal Tax		$2.26

Service Period Total **$69.42**

Thank you for your payment of $77.44 on January 29, 2016

Total Amount Due $69.42

UPDATES

ComEd

- WAYS TO PAY: ComEd offers a variety of ways to Pay. Learn more at ComEd.com/pay
- WE ARE HERE FOR YOU: As of Feb. 1st, we'll be open 1 hour later. Call us from 7 am to 7pm Monday through Friday. 1-800-EDISON-1 ComEd.com/ContactUs
- APPLIANCE REBATES: Get Appliance Rebates from the ComEd Energy Efficiency Program to upgrade your appliances. ComEd.com/Rebates
- SCAM ALERT: ComEd will never call you to request cash or ask you to buy a prepaid credit card to pay a bill. ComEd.com/ScamAlert
- PART 280: View a copy of the ICC Commission 83 Ill. Adm. Code 280 rules at ComEd.com/Part280
- YOUR COMED BILL: Need help understanding your bill line item definitions? Please visit us at ComEd.com/UnderstandBill or call us at 1-800-334-7661
- ENVIRONMENTAL DISCLOSURE STATEMENT: ComEd's Environmental Disclosure Statement can now be found online at ComEd.com/EnvironmentalDisclosure
- Past due balances are subject to late charges.

6577-65-0100001-0001-0000001

SAMPLE

OTHER WAYS TO PAY YOUR BILL

Visit ComEd.com/PAY for more information including applicable fees for some transactions.

Online

Set up an automatic payment, enroll in paperless billing, or make a convenience payment at ComEd.com/Pay.

Mobile App

Download the ComEd mobile app on your Apple® or Android™ device to view and pay your bill, or manage your account.

Phone

Call us to make a convenience payment with a credit card, ATM card, or your bank account: 1.800.588.9477. (Fee Applies)

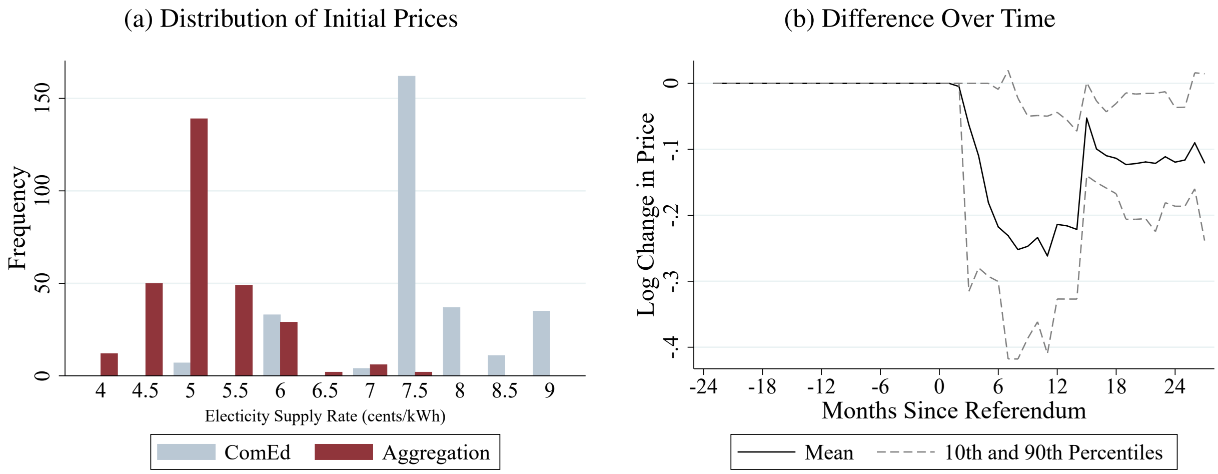
In-Person

Pay your bill in-person at many ComEd authorized agents located throughout the region. Visit ComEd.com/Pay for details.

When you provide a check as payment, you authorize us to use information from your check either to make a one-time electronic fund transfer from your account or to process the payment as a check transaction.

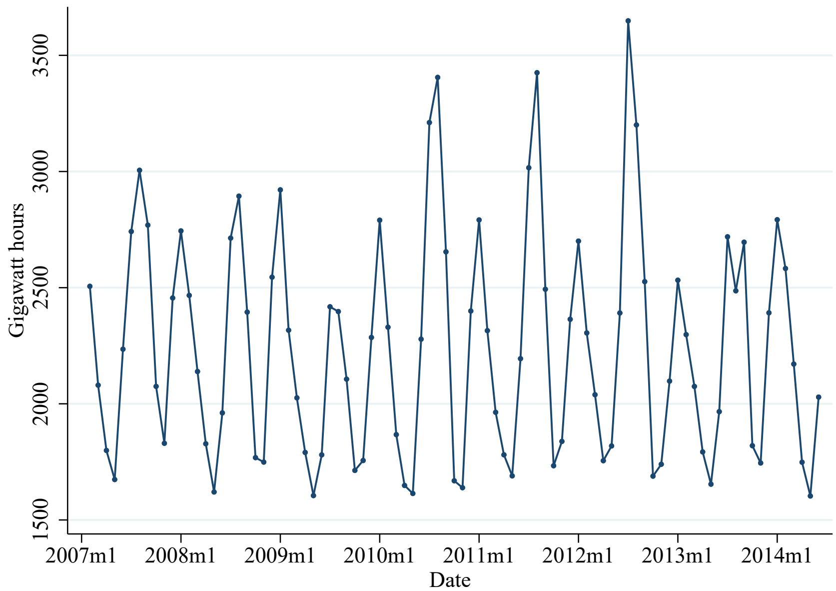
10% total recycled fiber

Figure A.5: Heterogeneity in Price Changes



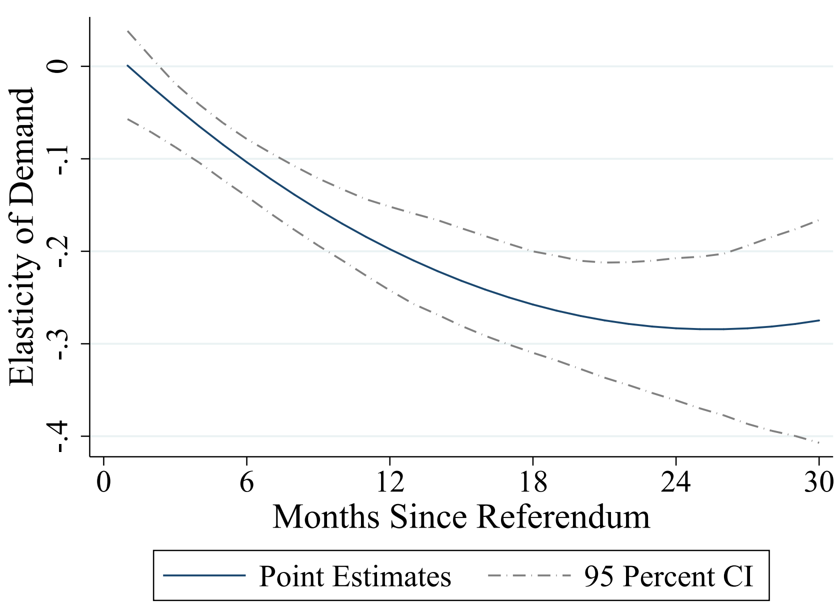
Notes: This figure displays the distribution of (log) price changes for aggregation communities relative to the contemporaneous ComEd price. Panel (a) provides a histogram of the initial aggregation rate and the corresponding ComEd rate in the first month of the program for each community. Panel (b) plots the the difference between aggregation and ComEd rates over time. The solid line displays the mean, and the dashed lines represent the 10th and 90th percentiles.

Figure A.6: Monthly Electricity Usage in ComEd Service Territories, 2007-2014



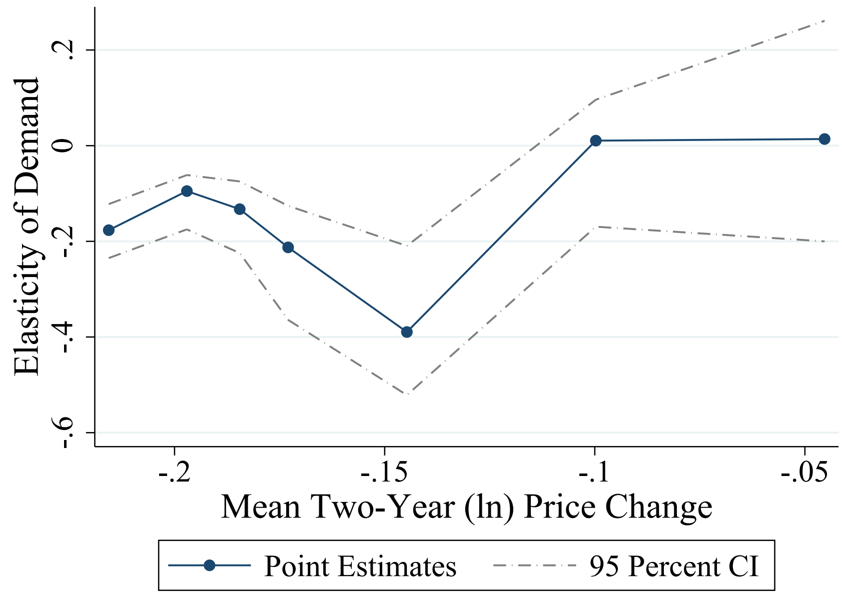
Notes: Figure displays total electricity usage across the ComEd service territories in our sample.

Figure A.7: Estimated Price Elasticities, Quadratic Fit



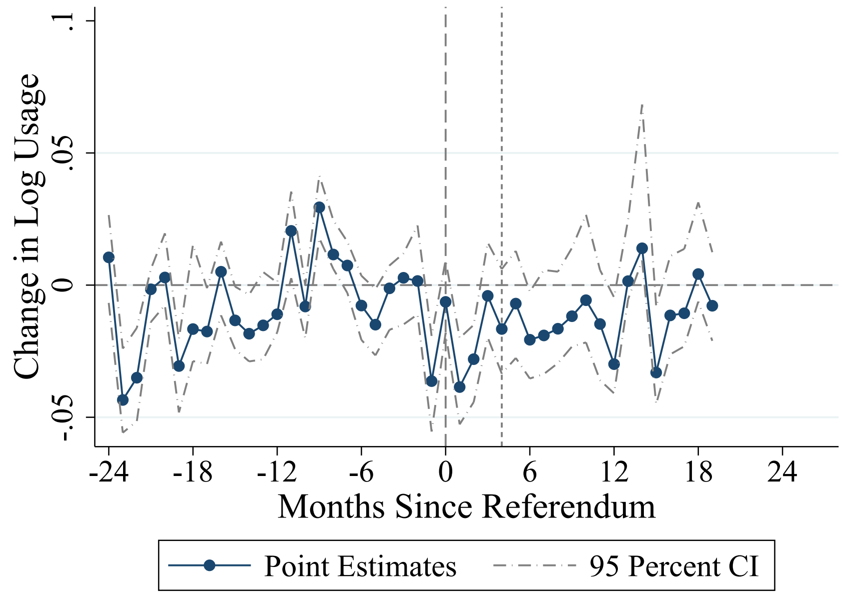
Notes: The reduced-form, time-dependent elasticity is estimated using a quadratic specification. Community-month changes in log usage are regressed on changes in log price, where the log price changes are also interacted with months since referendum and the square of months since referendum. These three parameters are used to construct the estimated elasticity response curve as a function of time. Confidence intervals are constructed via subsampling.

Figure A.8: Estimated Elasticities and Mean Log Price Change



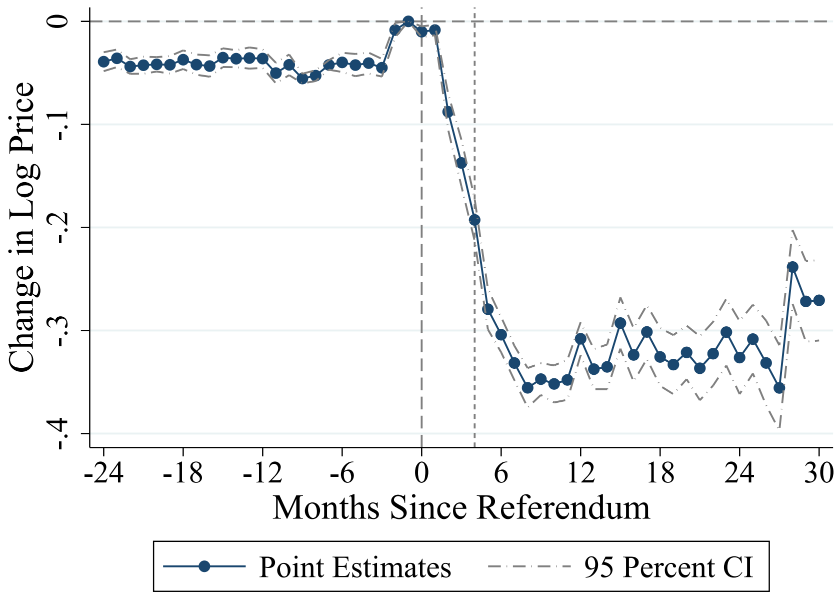
Notes: Communities are split into seven groups based on the average two-year price change they experienced in the first two years following their referenda. Elasticities are calculated separately for each group by pooling observations in this two-year period and estimating equation (5). The graph shows no relationship between the estimated group elasticity and the price change, mitigating concerns that the price change might be correlated with a community's elasticity of demand. Confidence intervals are constructed via subsampling.

Figure A.9: Effect on Log Usage: Communities that Passed but Did Not Implement Aggregation



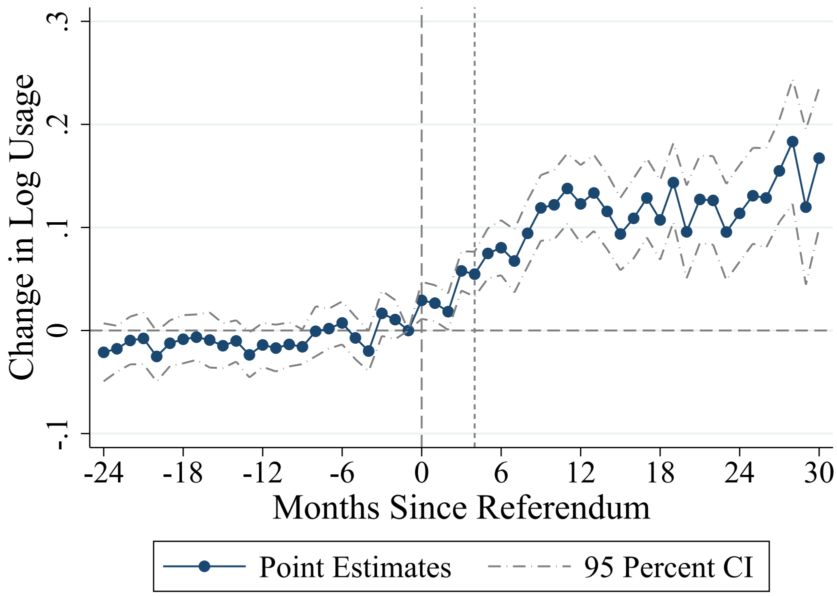
Notes: The figure displays estimates of the mean usage effect for the eleven communities that pass aggregation but never implement it. The effect is estimated relative to that community's five nearest neighbors, as defined by the difference-in-differences matching procedure outlined in the main text. The short dashed line indicates the median implementation date relative to when the referendum was passed. Confidence intervals are constructed via subsampling.

Figure A.10: Regression Estimates of the Effect of Aggregation on Electricity Prices, Communities that Passed Aggregation



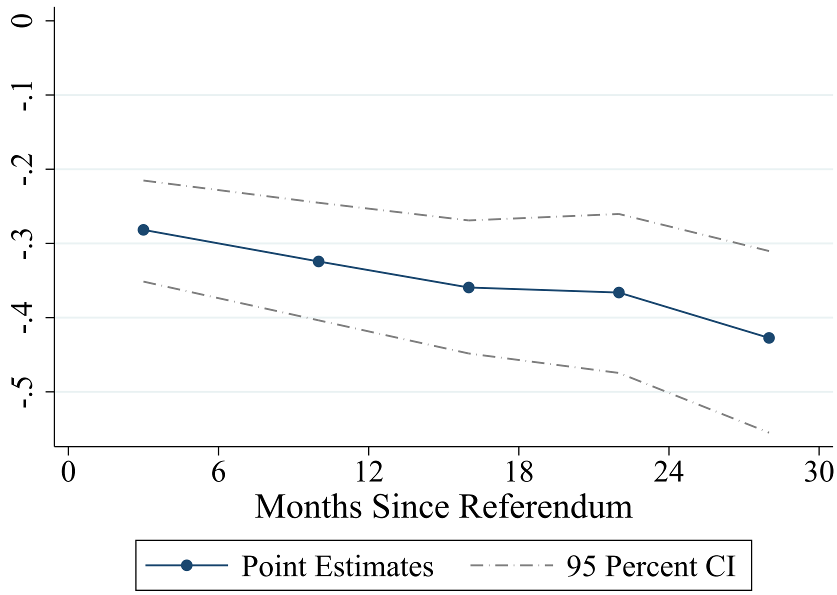
Notes: Outcome is the natural log of the electricity price. The first vertical dashed line indicates the date of the aggregation referendum. The second dashed line indicates the date of aggregation implementation. Regressions include month-by-year and community-by-month fixed effects. Standard errors are clustered by community. Sample includes only communities that passed aggregation at some point during our sample.

Figure A.11: Regression Estimates of the Effect of Aggregation on Electricity Usage, Communities that Passed Aggregation



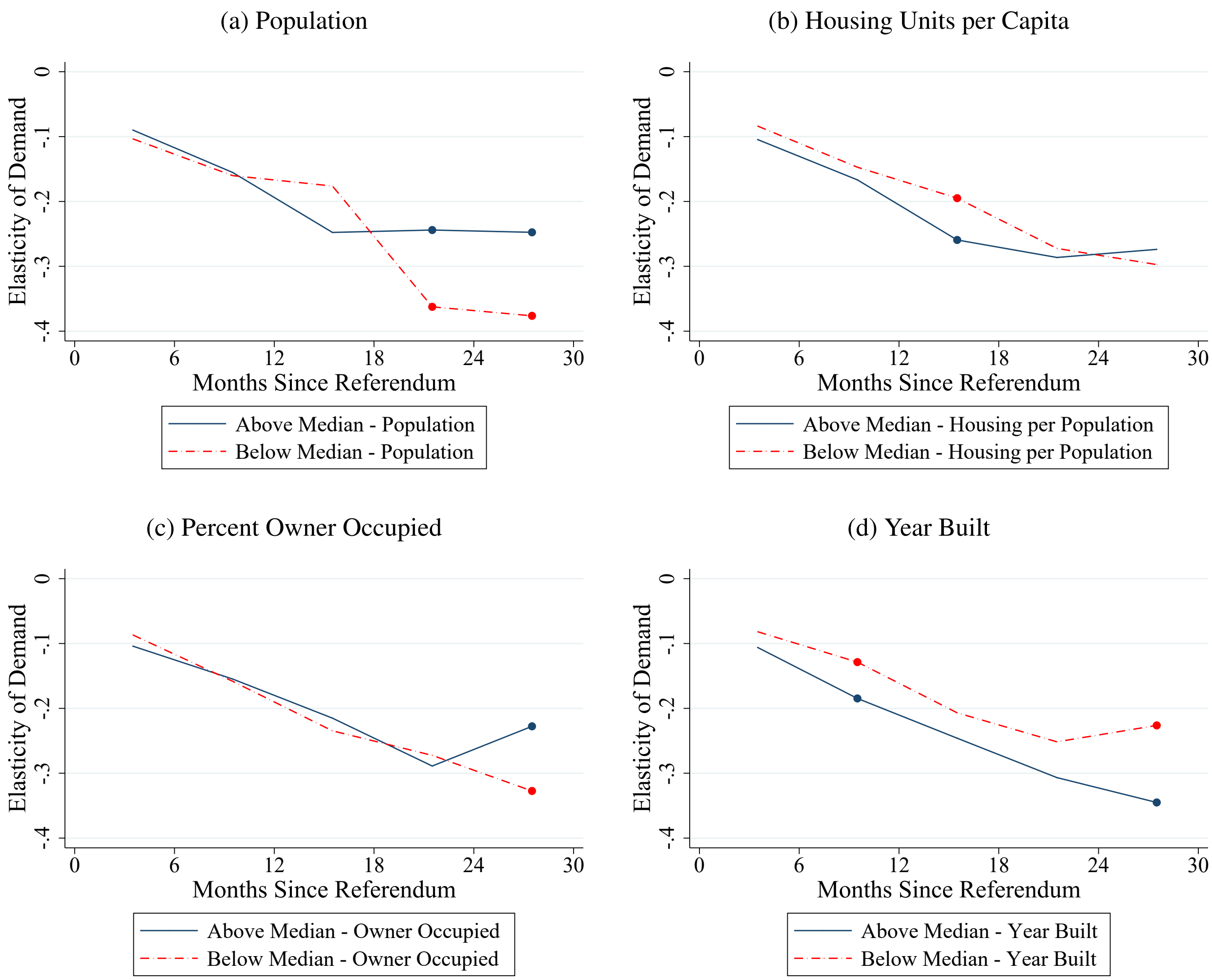
Notes: Outcome is the natural log of total electricity use. The first vertical dashed line indicates the date of the aggregation referendum. The second dashed line indicates the date of aggregation implementation. Regressions include month-by-year and community-by-month fixed effects. Standard errors are clustered by community. Sample includes only communities that passed aggregation at some point during our sample.

Figure A.12: Estimated Price Elasticities, Communities that Passed Aggregation



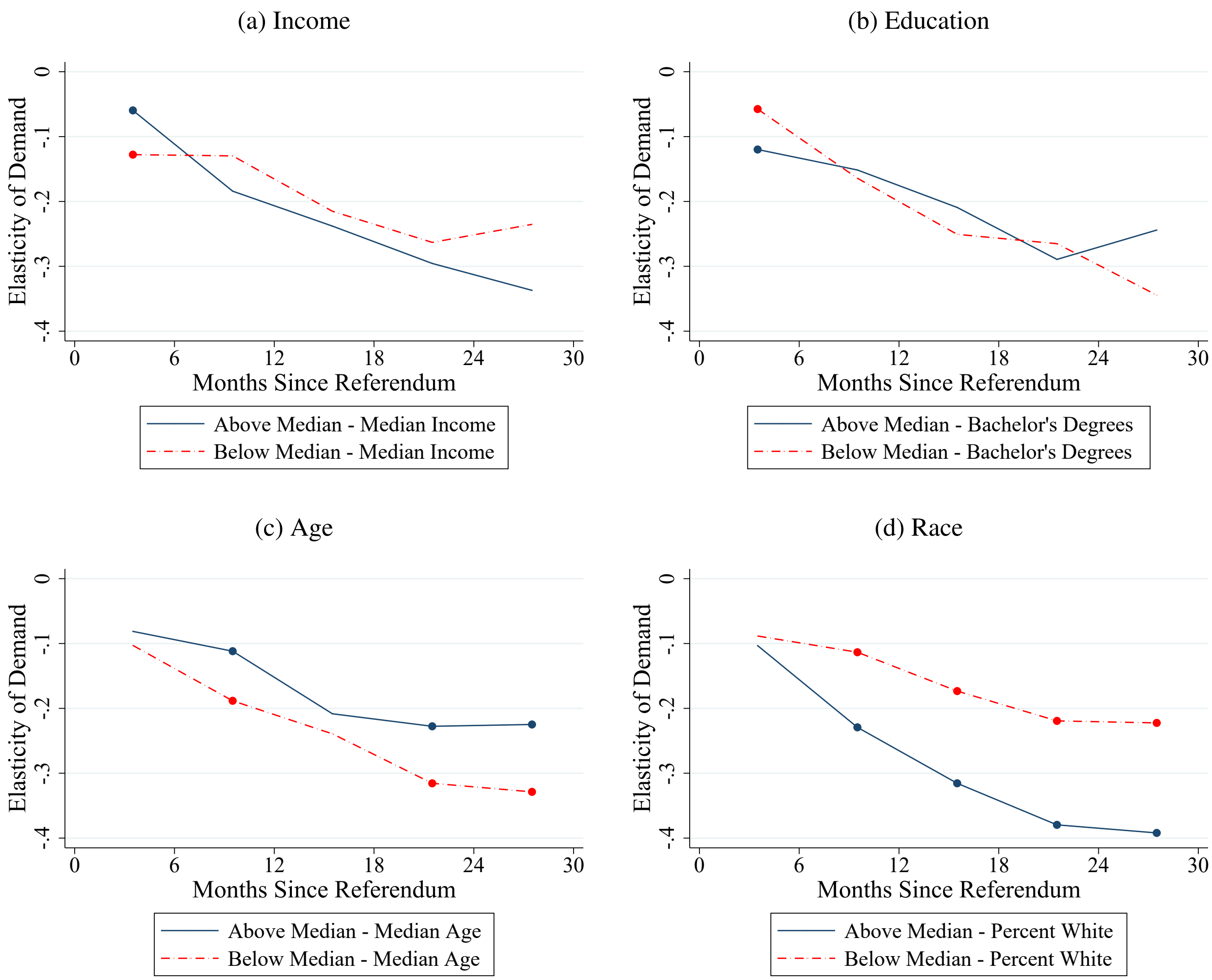
Notes: Sample includes only communities that passed aggregation at some point. Elasticities are calculated for each six-month period by regressing community-month changes in log usage on the observed change in log price. Confidence intervals are constructed by clustered bootstrap.

Figure A.13: Elasticities by Community Characteristics: Housing and population



Notes: These panels display elasticity estimates for communities that are below and above median for the specified characteristic. The estimates are from a reduced-form specification augmented with an interaction term for whether the community is in the upper half of the distribution. The regressions include eight interactions simultaneously: total population, housing units per capita, percent owner occupied, median year built, median income, percent with bachelor's degree, median age, and percent white. Coefficients significant at the 10 percent level are indicated by a marker.

Figure A.14: Elasticities by Community Characteristics: Socioeconomics



Notes: These panels display elasticity estimates for communities that are below and above median for the specified characteristic. The estimates are from a reduced-form specification augmented with an interaction term for whether or not the community is in the upper half of the distribution. The regressions include eight interactions simultaneously: total population, housing units per capita, percent owner occupied, median year built, median income, percent with bachelor's degree, median age, and percent white. Coefficients significant at the 10 percent level are indicated by a marker.