A Appendix (For Online Publication Only)

A.1 Conceptual Framework 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 (3):

$$y_{t} = K_{1} \sum_{s=1}^{\infty} (\lambda_{1})^{-s} h(t+s) + K_{2} \sum_{s=0}^{t-1} (\lambda_{2})^{s} h(t-s) + (\lambda_{2})^{t} \left(y_{0} - K_{1} \sum_{s=1}^{\infty} (\lambda_{1})^{-s} h(s) \right)$$
(10)

where $h(t) = \alpha_3 p_{t-1}$ and

$$K_1 = \frac{\lambda_1}{\alpha_2 (\lambda_1 - \lambda_2)}$$
$$K_2 = \frac{\lambda_2}{\alpha_2 (\lambda_1 - \lambda_2)}$$

with roots

$$\lambda_{1} = \frac{2\alpha_{1}}{1 - \sqrt{1 - 4\alpha_{1}\alpha_{2}}} > 1$$

$$\lambda_{2} = \frac{2\alpha_{1}}{1 + \sqrt{1 - 4\alpha_{1}\alpha_{2}}} < 1$$

We assume $4\alpha_1\alpha_2 < 1$, so that our solutions are real-valued.

Equation (10) 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 (10) becomes zero, so that consumption no longer depends on the initial condition, y_0 . It is straightforward to show that the solution to the first-order difference equation (4), the myopic "adjustment cost" model, depends only on past prices, and not on future prices.

A.2 Data Processing Details

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. This appears as large, discrete changes 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 dummies and a structural break indicator, where we 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 it 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.

One concern with this filter is that we may eliminate actual structural breaks arising from our policy of interest. The communities that are removed in this fashion are primarily small communities that did not implement aggregation. Further, the coefficient on the structural break indicator implies an unrealistic response to the price change.

A.3 Event Study Difference-in-Differences Estimates

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:

$$Y_{cmy} = \sum_{\tau = -24, \tau \neq -1}^{24} \beta_{\tau} A_{c\tau} + \beta_{25} A_{c,25} + \beta_{-25} A_{c,-25} + \alpha_{cm} + \alpha_{my} + \varepsilon_{cmy}, \quad (11)$$

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 main parameter of interest is β_{τ} . The variable $A_{c\tau}$ is an indicator equal to 1 if, as of month m and year y, community c implemented aggregation τ months ago. The month before aggregation implementation ($\tau = -1$) is the omitted category. To ensure that our estimated coefficients are relative to this category, we include indicators for aggregation having been implemented 25 or more months ago ($A_{c,25}$) and for aggregation being implemented 25 or more months in the future ($A_{c,-25}$). We include a full set of 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 in Section 5.

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

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

In this specification, $A_{c,0 \text{ to } 6}$ is an indicator variable equal to 1 if the community implemented 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 implemented aggregation between 7 and 12 months ago, and so on. The other variables are defined as in equation (11).

One could use this framework to estimate the effect of implementing aggregation by comparing communities that implemented aggregation to those that did not implement aggregation. However, this raises the concern that communities that did not adopt aggregation may not serve as adequate counterfactual for communities that did adopt aggregation. That is, the decision to adopt aggregation may be correlated with future energy usage. We therefore restrict our estimation sample to communities that implemented aggregation. Our main identifying assumption for these estimates is that, conditional on a host of fixed effects, the timing of aggregation adoption is exogenous with respect to electricity use.

Figure A.4 presents the change in electricity prices following aggregation, in logs, as estimated by equation (11). 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 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.4 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. There is an increase in the relative aggregation price 28 months after passing aggregation, which is due to the fact that electricity prices fell sharply for ComEd customers in June of 2013 (see Figure 3), the middle of our sample period. Despite this increase, prices in aggregation communities remain significantly lower than those in the control group for the entire sample period.

Figure A.5 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.

Table A.3 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 (12). Overall, the results consistently show large and significant price drops. 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 at around 0.3 log points by the end of the first year. These estimates are robust to including different fixed effects.

Table A.4 shows the estimated change in usage as estimated by equation (12) 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.6 shows the elasticities implied by the two preceding tables. Specifically, we show the ratio of coefficients from Tables A.4 and A.3, which estimate the aggregation-induced change in electricity quantities and prices, respectively. Because the outcomes are in logs, their ratio will be approximately equal to the elasticity. The implied elasticity ranges from -0.33 7-12 months after passage of aggregation to -0.45 two and a half years after passage.

A.4 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:²⁵

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.7 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.8 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.9 and A.10 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.10) will change. Otherwise her bill will remain the same.

²⁵From 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.

Appendix Tables

	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)		

Table A.1: Matching Estimates of the Effect of Aggregation on Usage and Prices, Monthly

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Estimates are constructed by a nearest-neighbor matching approach where each MEA town is matched to the five non-MEA towns 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.

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

Table A.2: Comparison of Tuning Parameters for Subsampling

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.

	(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	Х	Х		
Month and Year Fixed Effects	Х		Х	
Month-by-Year Fixed Effects		Х		Х
Community-by-Month Fixed Effects			Х	Х
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

Table A.3: Effect of Aggregation on Electricity Prices, Communities that Passed Aggregation

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.

	(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	Х	Х		
Month and Year Fixed Effects	Х		Х	
Month-by-Year Fixed Effects		Х		Х
Community-by-Month Fixed Effects			Х	Х
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

Table A.4: Effect of Aggregation on Electricity Usage, Communities that Passed Aggregation

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

Appendix Figures



Figure A.1: Estimated Price Elasticities, Monthly

Notes: Elasticities are calculated for each month by regressing community-month changes in log usage on the observed change in log price. Confidence intervals are constructed via subsampling.

Figure A.2: 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.3: Estimated Elasticities and Mean Log Price Change

Notes: Communities are split into seven groups based on the average two-year price change. Elasticities are calculated separately for each group. The graph shows no relationship between the estimated group elasticity and the price change, mitigating some concerns about endogeneity. Confidence intervals are constructed via subsampling.

Figure A.4: 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.5: 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.6: 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 bootstrap.

Figure A.7: 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 <u>www.DynegyEnergyServices.com</u> 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: <u>www.pluginillinois.org</u> and <u>www.ComEd.com</u>. You may request a list of all supply options available to you from the Illinois Power Agency.

Sincerely,

Targer

Christopher J. Lauzen Board Chairman Kane County

See Reverse for Frequently Asked Questions...

Kurt R. Kojzarek Development Committee Chairman Kane County

Figure A.8: Example of an Opt-Out Card

				PLACE
			2	2
	MC SQUARED ENERGY SEE	RVICES, LLC		
	344 South Poplar Street			
	Hazieton, PA 18201			
Opt-Out by re	turning this form: I wish to opt-	out of the Village	of South	Barrington electric
Opt-Out by re aggregation program	turning this form: I wish to opt- n and remain with my current provid	out of the Village der. By returning th	of South is signed fo	Barrington electric rm, I will be exclud
Opt-Out by re aggregation program from this opportunit	turning this form: I wish to opt- n and remain with my current provic ty to join with other residents in the	out of the Village der. By returning th electricity aggregat	of South i is signed fo	Barrington electric rm, I will be exclud
Opt-Out by re aggregation program from this opportunit You must mail this fo	turning this form: I wish to opt- n and remain with my current provid ty to join with other residents in the orm by June 15, 2012	out of the Village der. By returning th electricity aggregat	of South is signed fo ion program	Barrington electric rm, I will be exclud 1.
Opt-Out by re aggregation program from this opportunit You must mail this fo Name:	turning this form: I wish to opt- n and remain with my current provid ty to join with other residents in the orm by June 15, 2012	out of the Village der. By returning th electricity aggregat	of South i is signed fo ion program	Barrington electric rm, I will be exclud 3.
Opt-Out by re aggregation program from this opportunit You must mail this fo Name: Service Address:	turning this form: I wish to opt- n and remain with my current provid ty to join with other residents in the orm by June 15, 2012	out of the Village der. By returning th electricity aggregat	of South I is signed fo ion program	Barrington electric rm, I will be exclud
Opt-Out by re aggregation program from this opportunit You must mail this fo Name: Service Address:	turning this form: I wish to opt- n and remain with my current provid ty to join with other residents in the orm by June 15, 2012	out of the Village der. By returning th electricity aggregat	of South is signed fo ion program	Barrington electric rm, I will be exclud a.
Opt-Out by re aggregation program from this opportunit You must mail this fo Name: Service Address: City, State, Zip:	turning this form: I wish to opt- n and remain with my current provid ty to join with other residents in the orm by June 15, 2012	out of the Village der. By returning th electricity aggregat	of South i is signed fo ion program	Barrington electric rm, I will be exclud 1.
Opt-Out by re aggregation program from this opportunit You must mail this fo Name: Service Address: City, State, Zip: Phone:	cturning this form: I wish to opt- n and remain with my current provid ty to join with other residents in the orm by June 15, 2012	out of the Village der. By returning th electricity aggregat	of South i is signed fo ion program	Barrington electric rm, I will be exclud h

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Figure A.9: Example of a ComEd Bill (page 1 of 2)

Figure A.10: Example of a ComEd Bill (page 2 of 2)

