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AUTOMATIC BILL PAYMENT AND SALIENCE EFFECTS: EVIDENCE FROM ELECTRICITY CONSUMPTION

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Abstract—The introduction of automatic bill payment (ABP) programs in 2005 eliminated the need for consumers to view recurring bills. If those enrolled in ABP programs offered by utilities and other service providers forgo inspection of their recurring bills, then price salience declines, prices perceived by boundedly rational agents fall, and consumption increases. This paper considers the impact of such programs on consumer demand and welfare and empirically tests whether enrollment in such programs increases demand. Results show ABP enrollment increases residential electricity consumption by 4.0% and commercial electricity consumption by as much as 8.1%. Enrollment in programs designed to smooth seasonal variation in monthly utility bills of low-income customers results in 6.7% greater electricity use.

I. Introduction

IN standard theory, the consumption decisions of rational agents are invariant to the salience of product attributes. And yet if cognitive ability is constrained or if attention is itself a scarce resource, then agents may, in the course of decision making, overweight information that is easily recalled or prominent (Simon 1955; Tversky & Kahneman, 1974). Motivated by such insights from psychology, economists have demonstrated that individuals are less responsive to shipping fees than to auction prices on eBay (Brown, Hossain, & Morgan, 2010; Hossain & Morgan, 2006), rebates for car purchases than to car purchase price (Busse, Silva-Risso, & Zettelmeyer, 2006), taxes excluded from product prices than to taxes included in prices (Chetty & Saez, 2005; Chetty, Looney, & Kroft, 2009), income tax incentives than to sales tax incentives (Gallagher & Muehlegger, 2011), and earnings statements issued early in the week than earnings statements issued just before the weekend (DellaVigna & Pollet, 2009).

Consumer inattention to less prominent prices explains the persistence of shrouded add-on prices (e.g., parking and Internet fees associated with hotel accommodations and transaction and minimum balance charges associated with checking accounts). The proliferation of add-on prices for checked baggage, seat assignments, telephone bookings, and other components of air travel garnered the attention of U.S. regulators in 2011. In 2012, they required fare advertisements to include all mandatory taxes and fees and weighed additional rules on the disclosure of optional fees, like those for checked baggage. In short, economists, regulators, and firms recognize that inattention to the less salient components of product prices generates systematic biases in agents' consumption decisions.

Given that the manner in which prices are displayed is potentially important in consumer decision making, this paper considers whether enrollment in automatic bill payment programs affects consumption of goods and services regularly procured by recurring payments, like telecommunications and gas, electric, and water utility services. Voluntary automatic bill payment (ABP) programs permit the timely payment of recurring bills by automatic credit and debit card transactions or deposit account withdrawals without requiring individuals ever to view their bills. Historically, such transactions were initiated by individuals who were obligated to view their bills in order to transmit to service providers the funds necessary to avoid penalties associated with delinquency. Absent certain penalties for inattention to recurring payments, the incentive for consumers to attend to billing records is diminished. Consequently, inattention to accounts serviced by ABP programs may increase, reducing the price salience of products and services financed by those accounts and potentially inducing consumption above levels that would be chosen with full attention to price.

The use of ABP grew quickly at the turn of the century, following a broader trend in developed countries of growing reliance on electronic payments, like credit and debit card transactions, and diminishing use of paper-based payments, especially checks. The growing popularity of ABP mechanisms can be attributed to perceived benefits to retailers and service providers in the form of reduced billing transactions costs and greater certainty of timely payment. Consumers benefit from convenience and from avoided postage costs and penalties for delinquency (Mastercard, 2006; Visa, 2006). It is estimated that among Internet-connected households in the United States, 41% of all recurring bills are paid automatically (Fiserv, 2010) and that two-thirds of consumers with recurring bills use automatic payment mechanisms. By 2005, 53% of credit or debit cardholders in the United States paid recurring telephone bills automatically, and 44% and 37%, respectively, paid recurring cable television and utility

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bills automatically. Survey results suggest roughly that $23 trillion worth of bill payments in the United States are transacted automatically. In Great Britain, three in four consumers made at least one recurring payment automatically in 2010 (Payment Council, 2010).

To my knowledge, this paper is the first to estimate the causal effect of ABP enrollment on firm and household consumption. The customer-level data necessary for such analysis across the many industries that employ ABP mechanisms are typically proprietary and closely guarded. The regulated status of utility companies in some states, however, requires their compliance with state public record laws that mandate, in some circumstances, the disclosure of anonymized customer billing data. Thus, this paper employs monthly observations on electricity consumption among residential and commercial customers in South Carolina in order to test the prediction that the diminished price salience caused by ABP enrollment induces increased electricity consumption.

Estimates suggest that ABP enrollment causes a 4% to 6% increase in electricity use among residential customers and a 7.3% to 8.1% increase in consumption by commercial customers. This paper also provides the first credible estimates of the electricity consumption impact of budget billing programs that smooth bills of participating low-income residential customers over a twelve-month period. Consistent with the hypothesis that the price salience of deviations from mean consumption is diminished with enrollment in budget billing, it is estimated that enrollment in such programs increases residential electricity consumption by 6% to 7%.

Results presented here indicate that utility billing programs like ABP and budget billing (BB) interfere with efforts by regulated utilities and policymakers to boost energy price salience and reduce energy demand amid concern about anthropogenic climate change and the health and environmental damages caused by energy production and consumption. Such efforts include billions of dollars of investment in electricity infrastructure upgrades to deliver real-time use and price information to customers. The results of this analysis may also partly explain the energy paradox, a phenomenon in which individuals fail to make investments in energy efficiency that are expected to offer positive returns from energy cost savings (Allcott, Wozny, & MIT, 2010; Allcott, Mullainathan, & Taubinsky, 2012; Allcott & Greenstone, 2012; Gillingham, Newell, & Palmer, 2009; Sanstad & Howarth, 1994). The persistence of the energy efficiency gap is typically understood to be a consequence of the diminished salience of, and inattention to, future cost savings relative to upfront expenditures for energy-efficient technologies. If the price for energy consumption is itself insalient then future cost savings from efficiency improvements will be undervalued.

The salience effect induced by ABP mechanisms is perhaps most important in energy markets because of policy interest in reducing energy demand and because of the prevalence of ABP programs among utilities. Each of the ten largest electric utilities in the United States employs ABP, for instance. However, the salience effect from ABP enrollment that is estimated here in the context of electricity demand likely also has an impact on consumption decisions in other markets that rely on recurring payments, including markets for water and gas services, as well as telecommunications and insurance products.

ABP enrollment can induce overconsumption not just of marginal units when a consumer faces volumetric charges. If the consumer faces multipart tariffs and increasing block rate pricing, overconsumption can also occur when changes in individual demand, technology, and prices would induce a fully attentive individual to select a less costly product bundle or forgo consumption of the product entirely. Thus, even for products priced predominantly by fixed fees, like some mobile phone or cable television packages, diminished price salience may still result in increased consumption if consumers fail to select less costly bundles as prices change or as their product demands evolve or become known with greater certainty. Inattention to overage charges associated with many mobile phone contracts, for instance, can lead to costly consumption beyond that which would be chosen amid full attention.

This paper proceeds in section II by developing a theoretical model of price salience effects on consumption. In section III, the data and empirical model are introduced. Results and discussion are provided in sections IV and V, respectively. Section VI concludes.

II. Bounded Rationality and Salience Effects

Bounded rationality holds that agents seek to maximize utility subject to informational and cognitive constraints that may lead to mistakes in decision making (Simon, 1955; Tversky & Kahneman, 1974). Such decision errors are observed in laboratories and in the field, and their consequences are the subject of a growing literature (see DellaVigna, 2009, for a survey). While traditional models assume agents are perfectly informed, behavioral models acknowledge that attention may be a scarce resource. In this context, consumer demand can be altered as a consequence of changes in the salience of various product characteristics. Diminished price salience, for instance, is shown in a number of contexts to increase demand as perceived prices fall. Theory related to budget billing impacts on energy consumption was considered by McDermott et al. (1980) and Beard, Gropper, & Raymond (1998), so attention here is focused on developing an understanding of how more prevalent ABP programs affect consumption.

In order to parsimoniously model diminished price salience associated with ABP enrollment, let p be the exogenous price of a good X and assume individuals derive utility from consuming a numeraire, L, and M, which is produced from X according to $m = \alpha x$, where α is a technology parameter.[1] Though the framework is general, one may think of

[1] This is a simplification of the household production function (Lancaster, 1966).

X as electricity that is used to produce household activities, M. The individual utility function is of the quasi-linear form $U(l, m) = l + \theta V(m)$, where θ is a taste parameter that functions as a demand shifter and $V(\cdot)$ is a strictly concave and twice continuously differentiable function. Individuals maximize utility subject to the budget constraint $I = l + p \cdot x$.

Following DellaVigna (2009), inattention associated with enrollment in ABP is incorporated by assuming that individuals enrolled in ABP may perceive only a portion of the price of X. Thus, define the perceived price of X, $\tilde{p} = \delta p$, where $\delta \in (0, 1]$ is an inattention parameter with $\delta = 1$ denoting full attention and $\delta = 0$ denoting full inattention. A constant inattention parameter is assumed for simplicity.

The individual's perceived objective is

$$\begin{aligned} \max_{x} \quad & U(l, x) = l + \theta V(\alpha x) \\ s.t. \quad & I = l + \delta p x \end{aligned} . \tag{1}$$

Given the quasi-concave utility function and concave budget set, a solution to the consumer's problem exists at either a corner solution or a point of tangency along the budget set.

If it is optimal for an individual to consume L and M, then the solution to the individual's problem is defined by

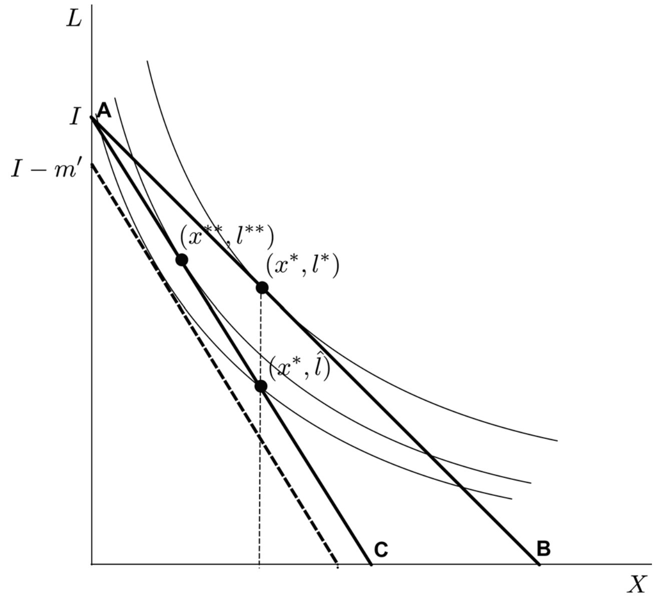
$$V'(m) = \frac{\delta p}{\theta \alpha}. \tag{2}$$

Greater inattention reduces the right-hand-side of equation (2), causing greater consumption of X in equilibrium because $V'(m) > 0$. Thus, ceteris paribus, an inattentive individual consumes more X than a fully attentive individual. The magnitude of "excess" consumption is increasing in the degree of inattention.

This result and associated welfare losses are depicted in figure 1, in which an inattentive consumer perceives the budget constraint defined by the line segment AB and optimizes by intending to consume (x^*, l^*). This point, however, lies outside the feasible set defined by the origin and the line segment AC. Consequently, in order to consume x^*, the inattentive individual must forgo more consumption of L than he perceives when he commits to consuming x^*. His consumption bundle lies on a lower indifference curve associated with the bundle $(x^*, \hat{l})$ that lies on the true budget constraint. Given that the slopes of the true and perceived budget constraints differ at x^*, the intersection of the lower indifference curve and the budget constraint at x^* is necessarily not a point of tangency, which implies there exists a bundle (x^{**}, l^{**}) that is feasible and yields higher utility.

Because the slope of the true budget constraint is greater than that of the perceived budget constraint for $\delta \in (0, 1)$, such a point must satisfy $x^{**} < x^*$. The difference $x^* - x^{**}$ represents the overconsumption or "excess" consumption of X due to consumer inattention. It results in a welfare loss equal to m' in figure 1, which represents the amount of income that could be taken from the consumer while still enabling him to achieve the utility associated with the bundle $(x^*, \hat{l})$ if the budget were allocated optimally between goods L and X, that is, bundle (x^{**}, l^{**}).

FIGURE 1.—OVERCONSUMPTION FROM INATTENTION TO MARGINAL PRICE



An inattentive individual perceives the budget constraint identified by AB and intends to optimize according to (x^*, l^*), which is, in fact, infeasible. The feasible set is defined by the budget constraint identified by AC. Having committed to consume x^* units of X, the individual can consume only $\hat{l} < l^*$ units of L, yielding less utility than the optimizing bundle (x^{**}, l^{**}) that is chosen by a fully attentive individual.

Individuals who enroll in ABP programs may be fully attentive to the cost of some baseline level of consumption of X, such as the cost of consumption at the point of enrollment in ABP. Nevertheless, they may exhibit inattention to changes in preferences θ, technology α, and price p, which should induce changes in optimal consumption of X and therefore cause the cost of recurring bills to change. Consider first the impact of changes in prices on the optimal consumption of the attentive and inattentive consumer. Because price is multiplied by the attention parameter, δ, on the right-hand side of equation (2), the change in consumption of M following a price change is increasing in δ or decreasing in the degree of inattention, that is,

$$\frac{\partial^2 m}{\partial p \partial \delta} = \frac{1}{\theta \alpha V''(M)} < 0, \tag{3}$$

where $\frac{\partial m}{\partial p} < 0$. Intuitively, the change in perceived price to which inattentive individuals respond is only a fraction of the true price change, which causes responsiveness to price changes to diminish as salience falls. An inattentive individual increases consumption less in response to price declines and reduces consumption less in response to price increases than the fully attentive individual. As electricity prices have tended to increase over the past decade, inattention is likely to have induced too little electricity conservation, all else equal.

Likewise, greater inattention to price reduces responsiveness to changes in technical efficiency and tastes:

$$\frac{\partial^2 m}{\partial\alpha\partial\delta} = -\frac{p}{\theta\alpha^2 V''(M)} > 0 \text{ and } \frac{\partial^2 m}{\partial\theta\partial\delta} = -\frac{p}{\theta^2\alpha V''(M)} > 0, \quad (4)$$

for $\frac{\partial m}{\partial\alpha} > 0$ and $\frac{\partial m}{\partial\theta} > 0$; that is, greater inattention to price decreases the responsiveness of consumption to taste changes and improvements in the technology of consumption. Inattention to price therefore diminishes the Jevon's paradox, or rebound effect, that is understood to diminish conservation from energy-efficiency improvements because of price and income effects. Thus, while inattention is often blamed for suboptimally high levels of energy consumption and while inattention to price may induce too little investment in energy efficiency, the increase in electricity consumption due to price and income effects associated with technical efficiency improvements is smaller as price insalience increases.

Though this analysis has examined the impact of price insalience on electricity consumption assuming a constant volumetric price and an internal solution to the consumer's problem, it is easily extended to nonlinear pricing and multipart tariffs. Inattention to price can also result in consumption errors in the presence of corner solutions and multipart tariffs, which characterize the pricing regimes for several goods subject to ABP, like utilities and telecommunications services. For instance, amid an increasing block pricing regime, an inattentive consumer will sooner increase consumption beyond a kink in the budget constraint because he perceives less of the incremental increase in price than does the fully attentive consumer. Overconsumption and welfare loss can also result from the inattentive consumer undertaking positive levels of consumption when the full attention optimum occurs at a corner solution with no consumption of the price-insalient good. Intuitively, the inattentive individual perceives a lower marginal price and a lower fixed "entrance" fee than the attentive individual who is dissuaded by the full entrance fee from consuming any X at all. Thus, price insalience can induce overconsumption at corner solutions, interior solutions, and kink points along budget constraints defined by multipart tariffs.

Interpretation of the inattentive individual's consumption beyond that which he would choose amid full attention as "overconsumption" or "excess consumption" and of associated differences in utility as welfare losses assumes no opportunity cost for attention to prices. Attention, however, may itself be a scarce commodity to be rationed. Sims (2003), for instance, modeled attention as a flow of information that could be bounded. To the extent that attention is bounded, inattention to prices may be rational as attention savings offset the costs of overconsumption. Rational inattention does not change the consumption impact of inattention, though it does affect the interpretation of such overconsumption as inducing welfare losses. In the context here, the attention burden required to maintain price salience is likely quite small, mitigating the rational inattention rationale for overconsumption. At the same time, however, the following empirical analysis suggests the private cost of overconsumption due to electricity price insalience is also fairly small for the typical household. The costs may be larger in other settings, however. Nevertheless, while behavioral economists may recognize the insalience-induced trade-offs associated with inattention, it seems unlikely the typical ABP account holder has made a rational choice to accept overconsumption in exchange for attention savings.

In a dynamic formulation of this two-good model, one may expect the individual to learn from his optimization error on realizing that consumption of l^* units of L is infeasible given x^* units of consumption of X. But in the context of a consumption bundle that contains hundreds of goods and services, it would be unlikely for an inattentive individual to identify the source of the optimization error on realizing the infeasibility of the preferred bundle. As Thaler (1986) has noted, learning requires immediate feedback, which markets may not always provide. Thus, the optimization error may persist with limited learning.

Regardless, a critique that repeated decision making and associated learning undermines the potential for persistent decision errors can be equally levied against much of the work on bounded rationality and salience effects, including that of Chetty et al. (2009), DellaVigna (2009), and DellaVigna and Pollet (2009), among others. Indeed, the potential for learning and for markets to enforce discipline in consumption decisions is central to critiques of behavioral economics (Friedman, 1953) and to debate over the external validity of laboratory experiments that showed deviations from standard theory (Mullainathan & Thaler, 2001; List, 2003; Levitt & List, 2007). Such critiques notwithstanding, the growing body of behavioral work, including accumulating evidence from the field in support of behavioral theories, demonstrates that decision errors can persist and affect market equilibria, that competition does not always save decision makers from their mistakes, and that arbitrage opportunities, where they exist, do not always enforce rationality (Akerlof & Yellen, 1985; Thaler, 1986; Conlisk, 1996; Mullainathan & Thaler, 2000; Gabaix & Laibson, 2006).

III. Data and Methods

In order to identify the average effect of enrollment in budget billing or ABP programs on electricity consumption, an extensive panel of monthly account-level electricity consumption is employed in a fixed-effects framework. Such a framework controls for selection on time-invariant unobservables and is robust to heterogeneous treatment effects.

Define y_{it} as the natural log of monthly electricity consumption (in kilowatt hours) of household (or commercial account) i in month t, such that

$$y_{it} = \gamma_i^A w_{it}^A + \gamma_i^B w_{it}^B + \xi^A w_{it}^A d_i^B + \xi^B w_{it}^B d_i^A + f(AcctDuration) + \lambda_t + c_i + \tau_{g,moy} + u_{it}, \quad (5)$$

where λ_t are a full set of time effects, c_i are observed and unobserved account-specific time-invariant heterogeneity, $\tau_{g,moy}$ is a postal-code-specific effect for each month of the year, $f(\cdot)$ is a cubic function of the account duration at time t that permits a distinct level effect for accounts that ever enroll in ABP, w_{it}^A is a treatment indicator equal to 1 if household i is enrolled in ABP in period t and 0 otherwise, w_{it}^B is a similarly defined treatment indicator for enrollment in budget billing, and u_{it} is an idiosyncratic error.[2]

Interest centers on the coefficients on the ABP and BB treatment indicators, w^A and w^B, respectively. Though time-invariant, account-specific characteristics are absorbed by account fixed effects and privacy requirements preclude identification of unique treatment effects according to account characteristics, one can nevertheless assume that most accounts enrolled in BB are low-income accounts. Therefore, by interacting an indicator for accounts that ever enroll in BB, d^B, with the ABP treatment indicator, it is possible to estimate a unique marginal effect of ABP on low-income accounts. This interaction and the symmetric interaction between the BB treatment indicator and an ABP-account indicator, d^A, are also included in equation (5).

Equation (5) allows heterogeneous treatment effects, permitting the behavioral response to enrollment in the billing programs to vary across households. Some households may enroll in the billing programs but remain perfectly informed about and attentive to monthly electricity costs. In such instances, enrollment should have no impact on electricity consumption. In other cases, electricity costs may become less salient and induce an increase in consumption as the perceived price of electricity falls.

For a large cross-section and a small time series dimension, estimation of the individual-specific treatment effects, γ_i^j for $j = \{A, B\}$ reflecting ABP and BB treatments, respectively, is problematic. However, a valid estimator of the average treatment effect can be obtained if

$$E(\gamma_i^j|\ddot{w}_{it}) = E(\gamma_i^j) = \gamma^j \; \forall t, \tag{6}$$

where $\ddot{w}_{it} = w_{it} - \bar{w}_i$. That is, individual-specific treatment effects can be correlated with the average propensity to receive treatment, $\bar{w}_i$, but not with the deviations in any time period (Wooldridge, 2002). In the context of a voluntary treatment regime, condition (6) constitutes a self-selection constraint that ensures program participation decisions are not systematically related to expected treatment effects. Here, the treatment affects potential outcomes through inattention or salience effects. Thus, the treatment effect is essentially unintended, and the self-selection constraint is likely satisfied. Intuitively, it is unlikely that an individual selects into ABP or BB because he expects to consume more electricity than he otherwise would. Conditional on equation (6), a good estimator of γ^j is $\hat{\gamma}^j = N^{-1}\sum_{i=1}^{N} \hat{\gamma}_i^j$.

In addition to equation (6) and the standard overlap assumption, consistent estimation of γ^j, the population-averaged treatment effect (PATE), also relies on strict exogeneity of treatment (Wooldridge, 2002; Imbens & Wooldridge, 2009; Rosenbaum & Rubin, 1983; Rubin, 1990). That is, the propensity to receive treatment and potential outcomes must be independent conditional on covariates. Though treatment assignment is nonrandom in this context, if equation (6) is satisfied, then strict exogeneity can only be violated by correlation between deviations in unobservable time-varying household characteristics and deviations in treatment status. But because nearly all households in these data that enroll in ABP and budget billing programs persist in the programs until their accounts are terminated, strict exogeneity is likely satisfied.[3] Indeed, as Wooldridge (2005) and Imbens (2004) noted, if $w_{it} = 1$ whenever $w_{ir} = 1$ for $r < t$, then strict exogeneity is a reasonable assumption. Intuitively, if enrollment in period r were induced by a stochastic positive shock to an underlying characteristic, like preference for convenience, then a stochastic negative shock to the same characteristic at a time $t > r$ should induce program withdrawal in period t. Moreover, as Imbens (2004) noted, even when individuals are presumed to choose treatment optimally, unconfoundedness will hold if the (potentially unobserved) characteristics determining treatment are unrelated to the outcome of interest. This is particularly true if the objective of the decision maker is distinct from the outcome of interest. In this case, an individual may optimally select into ABP because of a preference for convenience. But it is unlikely the individual selects into ABP because he seeks to influence consumption. The outcome of interest is a consequence of inattention and suboptimal decision making. If desire for convenience or other characteristics determining ABP enrollment are unrelated to inattention or cognitive constraints, as seems plausible, then even correlated changes in unobservable household characteristics and treatment status do not jeopardize unconfoundedness.

While it seems likely that deviations in household electricity consumption are independent of billing program enrollment decisions, it is nevertheless impossible to foreclose that enrollment decisions are correlated with other factors that are correlated with electricity consumption. For instance, enrollment in a utility ABP program may coincide with changes in

[2] Equation (5) is separately estimated with robust standard errors and standard errors clustered by postal code. The account fixed-effect controls for time-invariant factors that could induce error correlation within postal codes. The postal-code-specific month-of-the-year effect further absorbs time-invariant factors that vary systematically over the course of the year (e.g., postal-code-specific responses due to seasonal weather). The clustered standard errors are further robust to any remaining idiosyncratic error correlation; however, the number of clusters is 22. Angrist and Pischke (2008) suggest the Zeger and Liang (1986) standard errors implemented here are likely adequate for more than ten clusters. The first month of each account is dropped because of possible prorating at account origination.

The cubic specification of *AcctSeq* allows consumption to respond flexibly to the life cycle of an account. For example, one might expect consumption to ramp up quickly during the early period of a residential account as the residence becomes fully stocked with appliances. Thereafter, the account-sequence effect may level off or decline due to investment in energy-efficient appliances and so forth.

[3] Only 0.33% of accounts change enrollment status more than once.

Table 1.—Summary Statistics for Residential Accounts

	All Residential		Energy-Smart Homes		Standard Accounts		Summer-Conserving Accounts	
	All	Recent	All	Recent	All	Recent	All	Recent
Observations	1,191,941	509,061	1,039,500	523,365	1,128,458	551,800	1,198,890	500,265
Number of accounts	33,333	20,558	29,182	19,650	52,469	33,880	31,258	18,607
Number of ABP accounts	22,226	13,620	8,174	5,125	20,247	13,101	15,113	8,652
Number of BB accounts	4,073	2,088	608	326	1,499	805	1,965	956
Mean length of ABP	66.03	43.27	70.36	45.09	56.69	37.58	70.17	47.36
enrollment (months)	(43.24)	(27.59)	(46.26)	(30.17)	(40.84)	(26.22)	(42.32)	(26.66)
Mean length of BB	25.43	17.50	30.80	22.26	20.72	11.12	27.82	19.74
enrollment (months)	(34.71)	(23.40)	(41.44)	(1.75)	(31.79)	(16.27)	(35.63)	(23.73)
Mean date of account	476.67	522.57	486.65	528.95	483.03	525.69	475.06	520.52
initiation[a]	(46.19)	(28.22)	(49.38)	(0.04)	(48.61)	(29.83)	(44.94)	(26.92)
	{Oct 1999}	{Aug. 2003}	{July 2000}	{Feb. 2004}	{Apr. 2000}	{Nov. 2003}	{Sept. 1999}	{June 2003}
Mean date of ABP initiation[a]	497.88	533.11	504.72	537.95	499.80	534.07	493.66	529.28
	(48.93)	(30.50)	(52.08)	(0.63)	(48.07)	(30.80)	(47.07)	(28.51)
	{July 2001}	{June 2004}	{Jan. 2002}	{Oct. 2004}	{Sept. 2001}	{June 2004}	{March 2001}	{Feb. 2004}
Mean number months	22.76	11.40	24.94	12.46	21.63	10.86	22.20	10.66
before ABP	(35.97)	(20.93)	(40.52)	(23.96)	(33.93)	(0.04)	(35.05)	(20.17)
Mean log consumption	6.72	6.72	6.84	6.84	6.46	6.45	6.86	6.87
(kWh)	(0.78)	(0.78)	(0.72)	(0.73)	(0.84)	(0.85)	(0.72)	(0.72)

Standard deviations are in parentheses. Cluster-robust standard errors are in braces. Separate samples are drawn for each rate class and a random sample across all rate classes.
[a]Denominated in months since January 1960.

personal accounting or banking decisions, which could themselves be correlated with changes in household income. If an increase in household income prompts a change in banking practices, which in turn prompts enrollment in ABP, or if the increase in income increases preference for convenience, which prompts enrollment in ABP, then an observed increase in household electricity consumption could be due to an income effect rather than (or in addition to) a salience effect, biasing upward estimates of the salience effect. Though it is not possible in these data to rule out such possibilities, the data lend credence to a salience interpretation because, as discussed in the following section, the smallest changes in consumption due to ABP enrollment are exhibited by households that retain economic incentives for consumption monitoring because of their selection into specific pricing regimes. Moreover, it is not obvious, ex ante, whether such correlated events or decisions would bias up or down estimates of the treatment effect; it also seems plausible that a negative shock to income could induce changes in accounting and banking practices that induce ABP enrollment. Finally, results presented in the following section indicate that enrollment in budget billing programs increases consumption. It is unlikely that positive income shocks induce enrollment in budget billing programs, which are intended to aid low-income households, so consumption increases associated with this program are unlikely to be caused by income effects.

Although strict exogeneity is necessary to interpret $\hat{\gamma}^A$ and $\hat{\gamma}^B$ as estimates of PATEs, their interpretation as population-averaged treatment effects on the treated (PATTs) does not depend on independence of treatment status and potential outcomes. As it is unlikely that enrollment in ABP or BB would ever become compulsory, policy interest likely centers on the PATT rather than the PATE; the effect of treatment on those who will never receive treatment is of no particular policy interest (Heckman & Hotz, 1989; Heckman, Ichimura, & Todd, 1997). Still, if adoption rates increase over time, the PATT may converge to the PATE, increasing (decreasing) the average effect of ABP enrollment if adoption is negatively (positively) correlated with potential outcomes.

The principal set of data employed in this paper is a large panel of monthly observations on residential and commercial electricity consumption for accounts that originated from 1994 to 2010. These data were obtained pursuant to a public records request from Santee Cooper, a publicly owned electric utility in South Carolina that provides electricity to 164,680 retail customers located along the Atlantic coast between Charleston and Myrtle Beach. Due to privacy limitations in state public records law, personally identifiable information is exempt from disclosure. Consequently, each customer account is identified only by an account number and matched only to a five-digit postal code, limiting information about the account holders and their homes. The data contain more than 14.4 million monthly observations from more than 684,000 residential accounts, in addition to 3.32 million monthly observations from 167,500 commercial accounts. Thirteen percent of observed residential accounts enroll in ABP, while 0.7% enrolled in BB. Thirteen percent of observations are from ABP-enrolled accounts and 1.8% are from BB-enrolled accounts. Among commercial accounts, 3.4% enrolled in ABP. Due to computational constraints, the residential data were downsampled; ABP and BB accounts were oversampled to improve the efficiency of the fixed-effects estimation. Commercial accounts that never enrolled in ABP were also downsampled.[4] Tables 1 and 2 report summary statistics by pertinent rate class groups for residential and

[4] Review of the data revealed that during March and November 2009, account initiations exceeded the mean monthly initiations by more than 1.5 standard deviations. Accounts initiated during these months are omitted from this analysis. Likewise, in June 1996, the commercial account initiations exceeded the mean rate by more than one standard deviation. Commercial accounts initiated during this month are also omitted. The utility provided no information as to the nature of these anomalies.

TABLE 2.—SUMMARY STATISTICS, COMMERCIAL ACCOUNTS

	(1) All	(2) Recent
Observations	760,916	652,555
Number of accounts	20,948	16,462
Number of ABP accounts	1,958	1,814
Mean length of ABP enrollment (months)	67.82	66.38
	(44.32)	(42.51)
Mean date of account initiation[a]	499.67	509.80
	(44.72)	(42.25)
	{Oct. 2001}	{Aug. 2002}
Mean date of ABP initiation[a]	528.35	534.55
	(49.22)	(45.42)
	{Jan. 2004}	{Aug. 2004}
Mean number of months before ABP	28.41	28.57
	(37.21)	(36.73)
Mean log consumption (kWh)	7.08	7.11
	(1.77)	(1.76)

Standard deviations are in parentheses. Cluster-robust standard errors are in braces.
[a]Denominated in months since January 1960.

commercial account samples, respectively. The utility offers three major classes of residential rate codes, a rate for new and retrofitted energy-efficient homes, a discounted rate for homes committing to limiting summer energy consumption as a function of their own off-peak consumption, and a standard rate. Treatment effects are estimated separately for these major rate categories. Summary statistics in tables 1 and 2 are provided separately for sampled accounts initiated after 2000 ("Recent") and for sampled accounts irrespective of account origination date ("All").

IV. Results

Estimation results show evidence consistent with the hypothesis that diminished price salience associated with enrollment in automatic bill payment programs induces additional electricity consumption. In particular, enrollment induces a 4.0% increase in electricity consumption on average among all residential customers, as reported in column 1 of table 3 for robust and cluster-robust standard errors, respectively. (Because the dependent variable is the natural log of electricity consumption, coefficient estimates are interpreted as the decimal percent change in electricity consumption.) This estimate is significant at the 1% level. Restricting attention to newer accounts, particularly those initiated in the year 2000 or later ("Recent"), the salience effect increases to a highly significant 6.0% average increase in consumption, as reported in column 2 of table 3. These estimates are fairly consistent across the utility's conventional rate classes, ranging from a 3.61% effect for standard rate classes (column 5) to a 9.35% effect for recent energy-efficient homes (column 4).

The estimated impact of ABP enrollment on electricity consumption is (statistically) significantly smaller for accounts enrolled in the voluntary summer-conserving rate class that affords a rate discount in exchange for commitments to conserve peak-demand summer electricity consumption relative to own winter consumption. The ABP effect among these households is a statistically significant but relatively small 2.45% average increase in electricity consumption, which likely reflects the continued economic incentive these households face for monitoring their electricity usage. The relatively large magnitude of estimated ABP effects among energy-efficient homes may reflect a component of the rebound effect whereby consumers of energy-efficient products perceive a lower effective cost of energy-consuming activities (Jacobsen, Kotchen, & Vandenbergh, 2012). If smart home account holders believe they are especially efficient in consuming such activities, they may be less disposed to view electricity bills than are standard homeowners. Across all standard accounts, the effect of enrollment is greater for accounts originated since 2000.

The larger magnitude of the salience effect on recent accounts suggests that inattention to electricity bills is greater among new account holders, who tend to be younger. This could reflect a generational change in attention to financial accounts or the relatively lower financial literacy of younger account holders. That is, more senior account holders may be more likely to review electricity bills even after enrolling in ABP, thereby mitigating the diminution of price salience.

The magnitude of the salience effect is invariant to postal-code-level measures of median home value, household income, and age distribution from the 2000 U.S. Census, though there is limited variation in mean postal-code characteristics.[5] Information about account-specific characteristics is limited by privacy requirements of public record disclosure. Nevertheless, if one infers that BB enrollees are on average low-income, then a unique effect of ABP enrollment among low-income households can be identified. This estimate is obtained by including $w_{it}^{A}d_{i}^{B}$ in equation (5). The coefficient on this interaction term thus is interpreted as a marginal effect of ABP on accounts of type BB. It is negative and statistically significant when equation (5) is estimated across all residential and all recent residential accounts, as well as all and recent summer-conserving accounts and all energy-smart homes. The magnitude of these marginal effects is similar to the main ABP effect, which suggests that insalience-induced overconsumption among low-income houses is low. Given that budget billing programs are designed to alleviate budget shortfalls among low-income households during seasonal peak energy demand, it is reasonable to expect that such households are more attentive to monthly budgets. Moreover, the opportunity costs of their attention to recurring bills are likely to be lower than those of high-income households and their disutility from overconsumption is likely to be greater (assuming diminishing marginal utility of income). Conversely, the generally insignificant estimate of the coefficient on the symmetric interaction of an ABP enrollment account indicator with BB treatment status, $w_{it}^{B}d_{i}^{A}$ suggests neither a consistent nor a significant marginal effect of BB enrollment among ABP accounts. This conforms to theory as ABP enrollment is not suggestive of account-specific characteristics.

[5] Results are omitted for brevity, but are available from the author on request.

Table 3.—Effect of ABP and BB Enrollment on Residential Electricity Consumption
Dependent Variable: Log Consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All Residential		Energy-Smart Homes		Standard Accounts		Summer-Conserving Accounts	
	All	Recent	All	Recent	All	Recent	All	Recent
ABP	**0.0398*****	**0.0600*****	**0.0640*****	**0.0935*****	**0.0361*****	**0.0540*****	**0.0245*****	**0.0331*****
	(0.0047)	(0.0062)	(0.0048)	(0.0059)	(0.0052)	(0.0069)	(0.0058)	(0.0080)
	{0.0074}	{0.0050}	{0.0077}	{0.0086}	{0.0053}	{0.0087}	{0.0071}	{0.0084}
BB	**0.0673*****	**0.0742*****	**0.0361*****	**0.06732*****	**0.0816*****	**0.0912*****	**0.0629*****	**0.0561*****
	(0.0080)	(0.0111)	(0.0152)	(0.0232)	(0.0141)	(0.0208)	(0.0103)	(0.0138)
	{0.0084}	{0.0083}	{0.0124}	{0.0197}	{0.0139}	{0.0155}	{0.0092}	{0.0137}
ABP-BB Acct	**−0.0339*****	**−0.0386****	**−0.0612*****	−0.0369	0.0014	−0.0130	**−0.0364*****	**−0.0492****
	(0.0114)	(0.0190)	(0.0211)	(0.0347)	(0.0238)	(0.0358)	(0.0149)	(0.0149)
	{0.0094}	{0.0142}	{0.0199}	{0.0301}	{0.0130}	{0.0245}	{0.01443}	{0.0243}
BB-ABP Acct	0.0010	0.0024	**0.0313**	−0.0300	−0.0283	**−0.0475**	0.0176	**0.0614****
	(0.0127)	(0.0185)	(0.0237)	(0.0315)	(0.0251)	(0.0323)	(0.0172)	(0.0172)
	{0.0174}	{0.0198}	{0.0151}	{0.0245}	{0.0264}	{0.0243}	{0.0188}	{0.0326}
Acct Seq	**0.0023*****	**0.0027*****	**0.0015*****	**0.0015*****	**0.0048*****	**0.0084*****	0.0004	**−0.0003*****
	(0.0003)	(0.0006)	(0.0003)	(0.0005)	(0.0003)	(0.0006)	(0.0003)	(0.0003)
	{0.0003}	{0.0004}	{0.0003}	{0.0006}	{0.0005}	{0.0007}	{0.0004}	{0.0008}
Acct Seq-ABP Acct	−0.0002	**−0.0001**	−8.09e-05	4.52e-05	−7.58e-05	**−0.0005****	**−0.0002****	−0.0003
	(0.0001)	(0.0002)	(9.07e-05)	(0.0002)	(0.0002)	(-0.0002)	(9.81e-05)	(9.81e-05)
	{0.0002}	{0.0002}	{7.37e-05}	{0.0002}	{0.0001}	{0.0003}	{9.62e-05}	{0.0002}
Acct Seq^2	**−2.12e-05*****	**−4.94e-05*****	**−1.21e-05*****	**−2.29e-05*****	**−5.89e-05*****	**−0.0001*****	**−4.04e-06**	**−3.05e-06*****
	(3.17e-06)	(7.53e-06)	(2.76e-06)	(8.21e-06)	(4.61e-06)	(1.29e-05)	(3.17e-06)	(1.02e-05)
	{2.25e-06}	{9.16e-06}	{2.42e-06}	{1.03e-05}	{5.50e-06}	{1.44e-05}	{4.27e-06}	{9.00e-06}
Acct Seq^3	**7.92e-08*****	**2.99e-07*****	**4.11e-08*****	**1.26e-07****	**2.31e-07*****	**8.46e-07*****	**5.69e-09**	−1.91e-07***
	(1.44e-08)	(6.88e-08)	(1.18e-08)	(5.54e-08)	(2.34e-08)	(1.00e-07)	(1.47e-08)	(7.57e-08)
	{1.01e-08}	{5.49e-08}	{1.12e-08}	{6.65e-08}	{2.35e-08}	{1.22e-07}	{1.76e-08}	{6.51e-08}
Observations	1,191,008	508,667	1,038,863	523,032	1,127,267	551,362	1,197,915	499,909
Number of accounts	33,332	20,558	29,182	19,650	52,469	33,880	31,256	18,606

Robust standard errors are in parentheses; cluster-robust standard errors are in braces. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$ for robust standard errors. Bold denotes $p < 0.1$ for cluster-robust standard errors. Coefficient estimates are interpreted as the decimal-percent change in electricity consumption.

Table 3 also provides new evidence of the impact of budget billing programs on electricity consumption. Though the literature includes previous estimates of the impact of these programs on electricity consumption (McDermott et al., 1980; Williams et al., 1990; Beard et al., 1998; Ha, Williams, & Weber, 1993), none afford the internal validity of the fixed-effects estimation of this paper. On average, budget billing induces a 6.73% increase in consumption across all residential accounts, as shown in column 1 of table 3. This result is significant at the 1% level. Across all rate classes, the effect is highly significant, ranging from a 3.61% to a 8.16% effect as reported in columns 3, 5, and 7. The effect is larger among recent accounts except summer-conserving homes. These results are similar to those of Ha et al. (1993), who estimated that households enrolled in budget-smoothing programs consumed 10% more electricity than those not enrolled in the programs. They did not, however, control for selection. Beard et al. (1998) did not report readily interpretable results. Distinct from the estimated impacts of ABP enrollment, the magnitude of consumption increases due to budget billing does not vary consistently by the recency of account origination. It is notable that budget billing conceals from customers the marginal cost of deviations from mean consumption irrespective of whether bills are reviewed. Thus, it is not unexpected that the salience effects due to ABP are smaller than those due to BB. ABP induces insalience only among households that opt not to review regular bills, whereas BB induces insalience irrespective of bill-viewing habits. BB is likely also to relax short-term budget constraints among low-income households that face binding budget constraints during periods when electricity consumption is relatively high. When the budget constraint is relaxed, households consume more of normal goods.

An additional set of results examines whether diminished price salience due to ABP enrollment also affects electricity consumption of commercial account holders. As reported in column 1 of table 4, ABP enrollment induces a statistically significant 7.3% increase in electricity consumption across small and medium-sized commercial and municipal accounts.[6] The effect is slightly but statistically significantly larger (8.1%) among recent accounts. These results are surprising if commercial account holders employ professional financial services or monitor budgets more closely than households, in which case ABP enrollment should not induce diminished price salience. However, 95% of the commercial accounts are for small commercial enterprises (that consume less than 7,500 kWh per month). Small commercial account holders may not exhibit any more financial literacy than homeowners and may not employ anyone who does. Principal-agent problems could also induce a salience effect among commercial account holders.

[6] The data include only one large commercial account that originated and enrolled in ABP from 1994 to 2010.

TABLE 4.—EFFECT OF ABP ENROLLMENT ON COMMERCIAL ELECTRICITY CONSUMPTION
Dependent Variable: Log Consumption per Day

	(1) All	(2) Recent
ABP	**0.0733*****	**0.0814*****
	(0.0226)	(0.0250)
	{0.0207}	{0.0325}
Acct Seq	−0.0572	0.1034
	(0.0857)	(0.2177)
	{0.1150}	{0.2180}
Acct Seq-ABP Acct	−0.0002	0.0001
	(0.0004)	(0.0006)
	{0.0004}	{0.0007}
Acct Seq^2	**−3.47e-05*****	**−5.49e-05*****
	(9.90e-06)	(1.64e-05)
	{1.17e-05}	{1.73e-05}
Acct Seq^3	**1.25e-07*****	**2.27e-07*****
	(4.93e-08)	(9.92e-08)
	{5.57e-08}	{8.20e-08}
Observations	624,361	387,821
Number of accounts	20,200	13,394

Robust standard errors are in parentheses. Cluster-robust standard errors are in braces. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$ for robust standard errors. Bold denotes $p < 0.1$ for cluster-robust standard errors. Coefficient estimates are interpreted as the decimal-percent change in electricity consumption.

Results reported in tables 3 and 4 are consistent with the theory that as the cost of inattention to electricity bills declines, price salience diminishes, perceived prices fall, and consumption increases. Nevertheless, these results are subject to interpretation because household attention to electricity bills is not directly observed and because the analysis cannot fully control for account-specific, time-varying factors that may be correlated with ABP enrollment. A number of factors, however, corroborate the interpretation posited here, including tests of pseudo-outcomes (Imbens, 2004; Imbens & Wooldridge, 2009).

First, ABP treatment was assigned to a subset of residential accounts that never enrolled in ABP using nearest-neighbor matches to ABP accounts according to date of origination, postal code, and mean household electricity consumption. The treatment status and duration of these pseudo-treated accounts were determined entirely by the matched ABP accounts. Equation (5) was then estimated using only the non-ABP, non-pseudo-treated (control) accounts and the pseudo-treated non-ABP accounts. Results of this estimation are reported in column 1 of table 5. The effect of ABP on the pseudo-treated households is insignificant, consistent with the absence of a placebo effect. In other words, as expected, the treatment does not affect the nontreated accounts. The effect of true BB treatment is nevertheless highly statistically significant and consistent with estimates presented in table 3.

Second, a pseudo-outcomes test was performed on the ABP accounts before their enrollment in ABP. For each account, pseudo-treatment was imposed on ABP accounts j months before the true date of enrollment for $j \in \{13, 16, 19, 22, 25\}$. The pseudo-treatment effect was then estimated by equation (5) over all observations except post-ABP treatment observations for ABP accounts, as this would have contaminated the pseudo-treatment. The results of this estimation are reported in columns 2 to 6 of table 5. ABP treatment should have no effect on electricity consumption of the treated accounts before the treatment occurs, that is, before ABP enrollment, and this is confirmed in table 5. For the pseudo-treatment that imposes ABP enrollment thirteen months before treatment, the pseudo-treatment effect is estimated over only twelve post-pseudo-treatment months. While no statistically significant pseudo-treatment effect is estimated over this period, a significant effect is estimated over twelve months after the true treatment, as evidenced in column 7.

Finally, figure 2 presents the effect of ABP enrollment on household electricity consumption for 24 months prior to enrollment and 24 months after enrollment in an event-study framework. Specifically, it plots estimates of β and 95th percentile confidence intervals from the following regression estimated across residential accounts:

$$v_{it} = \sum_{j=-24}^{j=24} \beta_j 1\left[\phi_{it} = j\right]_{it} + w_{it}^B \gamma_i^B + \lambda_t + c_i + \tau_{g,moy} + u_{it}, \tag{7}$$

where $v_{it} = \frac{y_{i,t-1}+y_{i,t}}{2}$ is a rolling two-month average of monthly consumption by household and ϕ_{it} denotes the event month defined so that $\phi = 0$ for the exact month in which ABP enrollment occurs, that is, $\phi = -24$ for the event month 24 months before enrollment and $\phi = 24$ for 24 months after enrollment, and so on.

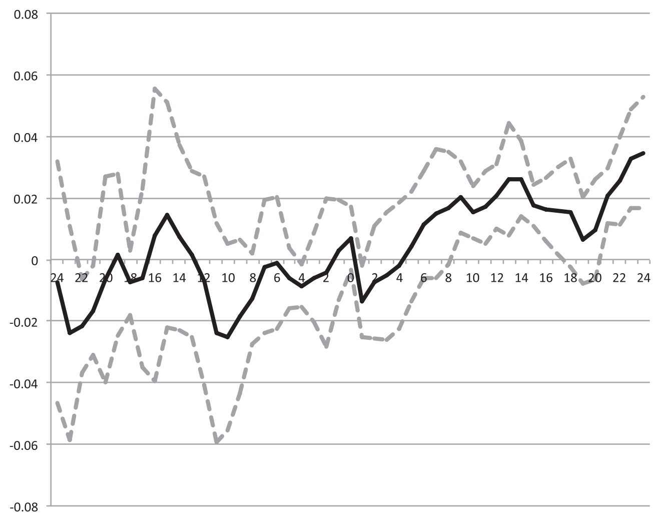
As Davis, Fuchs, and Gertler (2012) noted, event study analysis of changes in electricity consumption is likely to be compromised if such changes occur along margins that exhibit seasonal variation, as opposed to constant electricity demand. For instance, the event study framework is conducive to examining changes in electricity consumption due to refrigerator replacement but not air-conditioning replacement because electricity consumption by the former is approximately constant throughout the year, while the latter is likely to exhibit household-specific seasonal variation. In the context of this paper, it is likely that salience-induced increases in electricity consumption occur from increased use of nonconstant electricity-consuming appliances, like home heating and cooling appliances. Moreover, the speed at which price salience diminishes following ABP enrollment is likely to vary by household. Nevertheless, figure 2 evinces a pattern of ABP treatment effects consistent with an increase in electricity consumption due to ABP enrollment. The effect of ABP enrollment on electricity consumption is usually insignificant and never positive and significant prior to enrollment, as expected. Several months following the date of enrollment, however, ABP enrollment has a positive and statistically significant effect in all but two months following an initial treatment period. The effect is centered between 1% and 3.5% and seems to increase over time, consistent with the hypothesis posited in section II.

TABLE 5.—EFFECT OF PSEUDO-OUTCOMES ON RESIDENTIAL ELECTRICITY CONSUMPTION
Dependent Variable: Log Consumption per Day

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Residential Accounts Pseudo-Treatment on Treated					
	Treatment on Nontreated	(13 Months)	(16 Months)	(19 Months)	(22 Months)	(25 Months)	Treatment on Treated (12 Months Postenrollment)
ABP	−0.0022	0.0060	0.0048	0.0006	−0.0029	−0.0030	0.0248***
	{0.0052}	{0.0040}	{0.0043}	{0.0023}	{0.0032}	{0.0029}	{0.0078}
BB[a]	0.0786***	0.0666***	0.0666***	{0.0665}***	0.0665***	0.0665***	0.0619***
	{0.0259}	{0.0083}	{0.0083}	{0.0082}	{0.0082}	{0.0083}	{0.0099}
ABP-BB Acct	−0.0056						−0.0304
	{0.0187}						{0.0253}
BB-ABP Acct		−0.0133	−0.0134	−0.138	−0.0142	−0.0142	−0.0100
		{0.0298}	{0.0296}	{0.0297}	{0.0298}	{0.0297}	{0.0201}
Acct Seq	0.0196	0.0018***	0.0018***	0.0018***	0.0018***	0.0018***	−0.0071***
	{0.0290}	{0.0006}	{0.0006}	{0.0006}	{0.0006}	{0.0006}	{0.0007}
Acct Seq-ABP Acct		0.0005***	0.0005***	0.0006***	0.0006***	0.0006***	−8.34e-05
		{0.0001}	{0.0005}	{0.0001}	{0.0002}	{0.0002}	{0.0001}
Acct Seq^2	−1.78e-05**	2.33e-05***	−2.34e-05***	2.37e-05***	−2.39e-05***	−2.39e-05***	2.96e-05***
	{7.74e-06}	{4.78e-06}	{4.79e-06}	{4.78e-06}	{4.83e-06}	{4.82e-06}	{6.21e-06}
Acct Seq^3	4.95e-08	9.44e-08***	9.49e-08***	9.62e-08***	9.68e-08***	9.67e-08***	−1.21e-07***
	{4.56e-08}	{2.28e-08}	{2.30e-08}	{2.31e-08}	{2.33e-08}	{2.31e-08}	{2.57e-08}
Observations	652,547	477,561	477,561	477,561	477,561	477,561	661,601
Number of accounts	41,628	20,237	20,237	20,237	20,237	20,237	32,707

Cluster-robust standard errors are in braces. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
[a]True BB status of non-ABP accounts is retained; pseudo-BB treatment is not imputed.

FIGURE 2.—EFFECT OF ABP ENROLLMENT ON RESIDENTIAL ELECTRICITY CONSUMPTION



This figure plots estimated coefficients (solid black line) and 95th percentile confidence intervals (dashed gray lines) describing monthly electricity consumption before and after ABP enrollment. Time is normalized relative to the month of enrollment ($t = 0$). The regression includes household and postal-code-by-month-of-sample fixed effects. Standard errors are clustered by postal code.

V. Discussion

Since at least the 1970s, energy conservation has been a priority of federal energy policy. By 2012, it took on greater urgency amid heightened concern about global climate change and other environmental and human health consequences of energy production and consumption. But as electric utilities and regulators undertook considerable effort to reduce residential electricity consumption by noncoercive means, especially by strengthening price signals to consumers, many utilities also employed one or more billing programs that this analysis suggests lead to greater electricity consumption by making the costs of consumption less salient amid inattention. While the magnitude of the estimated consumption impact of enrollment in budget billing is greater than the estimated impact of ABP enrollment, the latter is offered by more utilities, including each of the ten largest utilities in the United States, and is taken up by customers at considerably higher rates. Approximately one in four customers of Santee Cooper were enrolled in ABP in 2010. Thus, ABP is likely to have a significant aggregate impact on electricity consumption across the country. In fact, the estimated 4% increase in electricity consumption due to ABP enrollment among residential customers is expected to cause the average Santee Cooper customer enrolled in ABP to consume an additional 494 kWh per year at a cost of $47. Throughout the Santee Cooper service area, ABP increases residential consumption by an aggregate 16.6 million kWh per year, an amount equal to annual consumption of 14,800 typical homes in the service area.[7] ABP-induced increases in consumption cost the utility's residential customers approximately $1.59 million in 2010.

The 13% of commercial accounts enrolled in ABP in 2010 overconsumed 5.9 million kWh. The combined residential and commercial consumption increases due to ABP

[7] These statistics and those that follow assume ABP has a common effect on accounts initiated before 1994 that persist to 2010. These accounts were excluded from the empirical analysis because the date of account origination was not observed.

resulted in an estimated 10,500 metric tons of carbon dioxide emissions in 2010, or about $232,000 in social costs, assuming a carbon price of $21 per metric ton of carbon dioxide (Greenstone, Kopits, & Wolverton, 2013). Extrapolating the estimates from this utility across the 125.7 million residential electricity customers in the United States in 2010, ABP is estimated to have induced 15.8 billion kWh of incremental consumption (equal to annual consumption of 1.5 million typical American homes) at an aggregate private cost of $1.82 billion and 8.6 million metric tons of carbon dioxide emissions at a social cost of $181 million.[8]

These results suggest that ABP programs interfere with energy and environmental policy goals by increasing residential and commercial electricity consumption. Notably, the magnitude of the estimated increase in electricity consumption due to ABP enrollment is large relative to other factors affecting electricity demand that have attracted the attention of economists and policymakers. For instance, empirical evidence suggests the decades-old practice of shifting clocks forward in the spring and backward in the fall in order to reduce energy consumption has an effect on residential consumption that is dwarfed by the ABP effect found here. Kotchen and Grant (2011) estimated that daylight saving time increases electricity consumption 1% on average, while Kellogg and Wolff (2008) found that an extension of daylight saving time in Australia during the 2000 Summer Olympic Games did not significantly affect electricity consumption. In the United States, at least 47 utilities in 21 states, including each of the 10 largest utilities, rely on social norms to achieve demand reductions by issuing home energy reports that compare a household's electricity consumption to that of its neighbors. The reports are estimated to reduce electricity consumption by 2% (Allcott, 2011), though the impact is heterogeneous. Relatedly, a review of pilot programs that introduce energy monitoring devices to households in order to boost price signals suggests such programs can induce 7% demand reductions among active users of the devices (Faruqui, Sergici, & Sharif, 2010).

ABP programs deliver benefits to utilities in the form of payment certainty and reduced transactions costs. They also afford customers convenience benefits. But this analysis suggests such benefits come at the cost of increased electricity demand that could relatively costlessly be avoided if the diminution of salience were avoided. Furthermore, if ABP-induced consumption increases are not a consequence of rational inattention, then consumer welfare would be improved by maintaining price salience. This could be accomplished, for instance, by requiring customers to open an e-mail containing an electronic bill or access the bill online before the automatic payment is transacted. Such a one-click payment mechanism would retain most of the convenience benefits to consumers and low-transactions-costs benefits to utilities while restoring price salience among ABP accounts. Payment certainty may diminish, but it would likely still be greater than payment certainty under traditional payment mechanisms. By boosting price salience among ABP accounts, electricity demand could be relatively costlessly reduced while delivering welfare gains to consumers who overconsume electricity. In contrast, other demand-response programs come at considerable cost. Home energy reports cost approximately $1 per household per report and deliver demand reductions at a cost of $0.033 per kWh. Moreover, consumer welfare is diminished by forgone utility from the energy consumption that is sacrificed to achieve conservation. The magnitude of these welfare costs has not been estimated. More generally, Gillingham, Newell, and Palmer (2004) estimated that utility-based demand-side management programs and voluntary and information programs like the Energy Star voluntary label program achieve electricity conservation at a cost of $0.034 to $0.038 per kWh. Arimura et al. (2011) estimated the cost-effectiveness of demand-side management by utilities to be $0.06 per kWh. While many of the demand-side management policies pursued by utilities and regulators target the residential sector alone, efforts to mitigate the diminution of price salience associated with ABP programs could generate reduced electricity consumption in the commercial sector as well as the residential sector, again at virtually no cost.

While the implications of ABP-induced overconsumption are important in the setting of this empirical analysis, the electricity market, the theory developed in section II suggests these salience effects should not be isolated to energy consumption. Indeed, overconsumption from price insalience can occur across a wide range of pricing regimes characterized by recurring payments, including those employed by water and gas utilities, as well as home and mobile telecommunications service providers. Because consumer-level consumption data are proprietary in many of these other industries, it is difficult to estimate the degree to which ABP enrollment also induces overconsumption of other goods. However, because ABP programs are implemented across a range of goods and services providers and because the programs are increasingly popular among consumers, it is likely that overconsumption due to ABP-induced inattention is widespread. Because overconsumption may be greater among new account holders, as suggested by the empirical analysis here, and because of the growing popularity of ABP programs, the magnitude of ABP impacts is likely to increase.

Inattention to current prices also has implications for policy design, particularly because a justification for energy taxes and technology subsidies is the opportunity to improve the welfare of boundedly rational consumers. Allcott et al. (2012) analyze the choice between technology subsidies and fuel taxes in the presence of consumers who undervalue energy

[8] North Carolina and U.S. 2009 average emission rates obtained from the U.S. Environmental Protection Agency's eGRID 2012 Version 1.0, accessed at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html. 2010 U.S. electricity consumption and price data obtained from the U.S. Energy Information Administration "Summary Statistics for the United States, 2001–2011, accessed at http://www.eia.gov/electricity/annual/html/epa_01_02.html.

cost savings from energy-efficiency durable goods investments. A technology subsidy is favored amid only inattention to future prices, but an energy tax would be favored if optimization errors instead occur along the utilization margin because the policy would correct the optimization mistakes with less distortion to the choices of those who are optimizing correctly. This paper does not determine whether the overconsumption due to ABP occurs along the capital stock margin or along the utilization margin, though the within transformation of the fixed-effects estimation effectively controls for systematic differences in technology adoption between ABP accounts and non-ABP accounts. Further work is needed to identify along which margins consumption increases amid price insalience, as well as to consider the implications of price insalience for instrument choice in the Allcott et al. framework.

VI. Conclusion

Behavioral economists have theorized that agents are less responsive to information that is less salient. These theoretical predictions have been confirmed empirically in a variety of contexts. They motivate the hypothesis of this paper that enrollment in budget billing and automatic bill payment programs reduces price salience, causing residential electricity consumption to increase. After first developing a simple model to illustrate how electricity consumption may increase due to ABP enrollment, the hypothesis of insalience-induced increases in consumption was empirically tested using a panel of account-level commercial and residential electricity consumption data. Results suggest that ABP enrollment causes a 4% to 6% increase in residential electricity consumption, with the larger effects exhibited among accounts initiated after 2000. The magnitude of the salience effect is invariant to postal-code-level measures of median home value, household income, and age distribution. The greater effect of ABP among recent account holders suggests a generational effect that could cause overconsumption from diminished price salience to increase in coming years. Budget billing is shown to induce a 6% to 7% increase in electricity consumption among residential accounts. The results are largely invariant to the recency of accounts, consistent with the equal diminution of price salience for deviations from mean consumption among households that regularly review bills and those that do not. There is also robust evidence that ABP increases commercial electricity consumption.

This analysis suggests that changes to ABP and budget billing programs that mitigate the decline in price salience could contribute to energy conservation objectives of utilities and regulators and do so cost-effectively relative to other programs that have attracted the attention of researchers and policymakers alike. This research also contributes to a growing literature that documents the importance of information salience to the decision making of agents characterized by bounded rationality.

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