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Dynamic salience with intermittent billing: Evidence from smart electricity meters[☆]

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ABSTRACT

Digital tracking and the proliferation of automated payments have made intermittent billing more commonplace, and the frequency at which consumers receive price, quantity, or total expenditure signals may distort their choices. While this category of goods has expanded from household utilities, toll road access and software downloads to standard consumption goods paid by credit card or other “bill-me-later”-type systems, we know surprisingly little about how these payment patterns affect decisions. This paper exploits hourly household electricity consumption data collected by “smart” electricity meters to examine dynamic consumer behavior under intermittent expenditure signals. Households reduce consumption by 0.6–1% following receipt of an electricity bill, but the response varies considerably by household type and season. Our results also suggest that spending “reminders” can reduce peak demand, particularly during summer months. We discuss the implications for energy policy when intermittent billing combined with inattention induces consumption cycles.

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1. Introduction

The neoclassical agent takes account of all present and future expected costs and benefits when making decisions. Yet in many settings consuming a good and spending money on it are separate experiences, and the true costs of one’s actions are only revealed ex post and intermittently – often in the form of bills. Monetary costs may not be salient to the agent if the market environment makes prices or quantities opaque when consumption is happening, particularly if the agent is billed later for decisions that are made over time. The problem of salience is not simply one of uncertainty; forming rational expectations with uncertainty requires cognitive processing of the distribution of outcomes, while insalient costs facilitate inattention and incomplete cognitive processing (DellaVigna, 2009). An agent may overconsume if he becomes inattentive to his spending when price or quantity information is obscured.

Overconsumption has been demonstrated with static models in the context of toll road use (Finkelstein, 2009), alcohol purchases (Chetty et al., 2009), bank overdrafts (Stango and Zinman, 2011), and monthly electricity consumption (Sexton,

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2012). Yet the problem is a fundamentally dynamic one if actions taken when expenditure is not salient are hysteretic or deplete capital stocks, and if this type of spending is repeated. True expenditure is revealed eventually; how does realizing that one has recently been inattentive and overconsumed – and may soon repeat this behavior – affect present and future behavior? For how long after an expenditure signal (a bill) is received do agents remain attentive? These problems are very different from those faced by an impatient or even present-biased agent who simply places less weight on the future but still acts with full awareness of expected costs.

The number of market environments in which signals about accumulated expenditure are opaque or intermittent is large and growing. Health patients with chronic illnesses make sequential decisions about medical treatments at different points in time than they are billed for those decisions. Accounts allowing downloads of media, games, and software apps to smart phones and tablet PCs are typically linked to credit cards that are billed monthly. Often these accounts have a credit card number on file that can be accessed with a single click so the consumer need not even open their wallet, avoiding one last reminder about the incurred expense. Many subscription services and household utilities are moving or have already moved to automatic bank draft or credit card billing systems. Certain non-monetary costs of consumption can also be temporally disconnected from the consumption decision. For example, the health costs of over or under consumption of certain types of goods like fatty or sugary foods, harmful drugs, and chronic medicines, are not apparent at the time of consumption.

Problems with salience are the rule rather than the exception in a world in which people pay for a larger share of even basic consumption with credit cards, many additional types of consumption are billed weeks after consumption occurs, and many types of bill payments are automated. We should not be surprised by a consumer who is shocked at his own consumption or unhappy with the decisions that his past self has imposed on the wellbeing of his current self because a lack of salience can facilitate intertemporal moral hazard.¹ This poses costs and benefits for sellers, however, because opaque expenditure information can increase sales but also demand volatility when customers vacillate between overconsuming while inattentive and underconsuming to compensate for past or future actions.

In this paper, we focus on the dynamics of salience. In particular, we focus on a context in which agents are periodically exposed to information that is freely available (or perfectly salient) only in discrete intervals, between which agents forget the information. We ask whether consumption changes immediately following information exposure.² Using the motivating example of residential electricity consumption, we answer this question with evidence from a unique panel data set of hourly household-level electricity use for several thousand households in the San Diego suburbs. If electricity expenditures are only salient to consumers when they receive a bill, then consumers should adjust behavior at the point of salience (i.e., the beginning of the billing cycle) but then return to overconsumption as their attention to the bill fades. We test this prediction by studying changes in household consumption behavior throughout their monthly billing cycle. Such “recency effects” of intermittently salient information, or effects that decline as time passes, have been found with late payment fees for credit cards in Agarwal et al. (2013) and personalized home energy reports with normative and educational messages in Allcott and Todd (2012).³ In both cases, however, the information treatments are “unusual” in the sense that they are designed to draw the agent’s attention and alter behavior. We show that the same pattern of behavior is present with routine billing.

We find that households reduce consumption by 0.6–1% in the first week of a new electricity billing cycle. These impacts are more pronounced in the summer, particularly if the weather is hot when the bill arrives, and among larger households with more sensitivity to hourly weather fluctuations (which we take as an indication of air-conditioning use).⁴ Within the day, reductions persist through the peak hours of afternoon and early evening, providing the first evidence to our knowledge that reminding households about their spending can induce peak load reductions in addition to general conservation. We also examine differential responsiveness to billing information across households based on several novel measures of household composition and capital stock.

These results are consistent with several possible theories of salience and inattention. Households could be rationally inattentive and simply forgo the costs of calculating the cost of energy at every instant within the month.⁵ On the other hand, limited cognitive processing of opaque expenses may systematically bias down the effective expense used in decision making, in which case households would consume as if the good is cheap when the expenditure is not salient, and consume

¹ This is in contrast to rational addiction models (e.g. Becker and Murphy, 1988) in which the agents act with full awareness of the intertemporal externality but engage in bad behavior anyway.

² Related literature focuses on different aspects of the dynamic problem; Karlan et al. (2010) present a dynamic model with inattention to uncertain future costs (e.g., car repairs or durable goods replacement) rather than periodic inattention to current spending, and Grubb and Osborne (2012) have a dynamic component to learning about preferences in the context of insalient cell phone usage costs. The rational inattention literature (e.g., Sims, 2003), which has primarily addressed problems in macroeconomics and finance, takes the point of view that agents face constraints in processing multiple flows of uncertain information, but information is nevertheless freely available; agents therefore exhibit inertia and respond sluggishly to aggregate updates but discretely to own shocks. This might be an appropriate explanation for the inertia and variability in electricity consumption but this is beyond the scope of this paper.

³ Allcott and Todd (2012) also find that reversion to past behavior is reduced when intermittent messages are maintained over a long period of time.

⁴ We also find evidence of consumption reductions near the bill due date, suggesting that payment may also have a salience effect. Absent specific information about individual dates of payment we do not focus heavily on these results.

⁵ However, it seems under this explanation rationally inattentive consumers should still form rational expectations about prices they haven’t bothered to calculate, in which case consumers should guess their effective prices correctly on average and not systematically overconsume in periods when price information is unavailable.

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