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Paulo Bastos
Lucio Castro
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Department of Research and Chief Economist

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Paulo Bastos*
Lucio Castro**
Julián Cristia*
Carlos Scartascini*

* Inter-American Development Bank
** Centro de Implementación de Políticas Públicas para la Equidad y el Crecimiento (CIPPEC)

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Abstract[*]

This paper exploits unique features of a recently introduced tariff schedule for natural gas in Buenos Aires to estimate the short-run impact of price shocks on residential energy utilization. The schedule induces a non-linear and non-monotonic relationship between households' accumulated consumption and unit prices, thus generating an exogenous source of variation in perceived prices, which is exploited in a regression-discontinuity design. The estimates reveal that a price increase in the utility bill received by consumers causes a substantial and prompt decline in gas consumption. Hence they suggest that policy interventions via the price mechanism, such as price caps and subsidies, are powerful instruments to influence residential energy utilization patterns, even within a short time span.

JEL classifications: L95, D12, L51, Q41, Q48
Keywords: Energy consumption, Elasticity of demand, Regulation of public utilities, Regression discontinuity design, Public policy

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1. Introduction

Suppose that energy prices experience a shock. Does energy consumption respond? How much and how promptly? These are key questions in the study of a wide range of macroeconomic, regulatory and environmental issues, such as the transmission channels of energy price shocks, optimal taxation and pricing policies in energy markets, and interventions to address climate change. Naturally, economists have a long-standing interest in estimating the price-elasticity of demand in energy markets.[1] Progress towards this aim has been complicated by an important identification challenge, however. Since consumers typically experience the same events at essentially the same time, it has been difficult to construct the equivalent of randomly assigned treatment and control groups and thereby ground the estimated price elasticities on a well-defined counterfactual (Reiss and White, 2008).

In this paper, we exploit unique features of a recently introduced tariff schedule for residential consumption of natural gas in the metropolitan region of Buenos Aires (Argentina) to estimate the short-run impact on residential gas consumption of price shocks. The new tariff schedule introduced a non-linear and non-monotonic relationship between annual previously accumulated consumption and unit prices, thus giving rise to an exogenous source of price variation. Therefore, the introduction of a threshold for defining unit prices based on previously accumulated consumption approximates a randomly assigned price differential for a large number of consumers located on each side of the tariff discontinuity, allowing us to build treatment and control groups to estimate the effect of interest. We estimate the demand effect of a price shock using a regression discontinuity (RD) design whereby the consumption levels of households situated barely above a sizable tariff discontinuity are compared with those of households located barely below.

Our estimates suggest that the price increase in the cost of gas consumption (as perceived by customers in their utility bill) induces a statistically significant, sizable and prompt decline in residential energy consumption: a 25 percent price increase reduces residential consumption in cubic meters by 3.8 percent in the subsequent two-month period. This result provides scant support to the widely held belief among policymakers and regulators that residential energy demand is highly inelastic (see, e.g., Hand, 2002). Indeed, it suggests that policy interventions

[1] Work on this topic, discussed in more detail below, dates to Parti and Parti (1980), Dubin and McFadden (1984) and Hsiao and Mountain (1985). Recent influential contributions include Reiss and White (2005, 2008).

via the price mechanism may constitute a powerful instrument to influence the patterns of residential energy utilization, even within a relatively short time span.[2]

The data on residential consumer prices and behaviors used in the estimations were drawn from the administrative records of the natural gas distribution company (MetroGAS S.A.). These records contain information on the price paid, and consumption patterns of every consumer (information which is the same as what consumers received in their billing).

As we explain in detail below, an important feature of our research design is that it exploits the specific information set available to consumers to estimate the effect of interest. For this reason, the resulting estimates are especially relevant for residential energy markets characterized by ex post billing where households infer changes in unit prices from the utility bill. Importantly, while it has long been emphasized that this feature of residential energy markets plays an important role in shaping consumption responses to price changes (Shin, 1985), there is still little direct evidence on whether and how promptly energy consumption responds to price variations inferred from utility bills.

This paper complements and extends several strands of existing research. A number of studies employ time series methods using data on energy prices and aggregate energy consumption (Liu and Lin, 1991; Krichene, 2002; Bushnell and Mansur, 2005). A related strand of work draws on cross-sectional survey data, including influential papers by Parti and Parti (1980), Dubin and McFadden (1984), Dubin (1985) and Reiss and White (2005). While these methods allow for the estimation of long-term impacts, the aggregated or cross-sectional nature of the data imposes relatively strong identifying assumptions. Furthermore, estimates yielded by cross-sectional data are, by construction, silent on the speed with which energy consumption adjusts to price shocks, an issue that is of key interest in a variety of policy contexts.

A related body of research estimates price-elasticities in the context of tariff field experiments, including early work by Hausman, Kinnucan and McFadden (1979), Acton and Mitchell (1980), Caves and Christensen (1980) and Parks and Weitzel (1984). Whereas this approach addresses some limitations of the time-series and cross-sectional evidence, it has been criticized on the ground that the (most often voluntarily-selected) set of participants are thoroughly informed about price changes at the outset, generating an informational context that

[2] This way, it may provide additional evidence for the discussion of the relative impact of prices compared to nudges for steering consumers' behaviors (Loewenstein and Ubel, 2010).

differs significantly from real-world situations in which households learn about price changes from utility bills or the press (Acton, 1982; Reiss and White, 2008).

In the paper that is perhaps closest to our own, Reiss and White (2008) use disaggregate billing data on electricity consumption from California to examine how price shocks and conservation appeals impact residential electricity consumption. Their estimates point to sizable short-run impacts on energy utilization. Focusing on the residential natural gas market, our paper complements and extends their work by providing evidence from a research design that allows us to approximate a random assigned price shock perceived from the utility bill.

The remainder of the paper is structured as follows. Section 2 provides background information on the market for natural gas in the city of Buenos Aires and the province of Buenos Aires and on the tariff schedule change. Section 3 describes the data employed. Section 4 describes the research design and provides important complementary evidence from a survey of consumers located near the discontinuity of interest. Section 5 presents the econometric results. Section 6 offers some concluding remarks.

2. Background

The tariff schedule for residential gas consumers in Argentina has experienced significant changes in the last three years. With the breakdown of the currency board regime ("Convertibility") in 2002, residential tariffs were frozen by the national energy regulatory agency, ENARGAS. Gas producing and distributing companies were compensated for the resulting revenue losses by a complex and expensive web of government subsidies. Expectedly, however, gas production and reserves started to decline from 2007 onwards, forcing the regulator to introduce changes in the tariff schedule.

Since the 1990s, the tariff for residential gas consumers in the greater metropolitan area of Buenos Aires (where more than 30 percent of the Argentine population lives) has been based on a three-tiered structure.[3] First, there is a fixed fee that does not vary with gas consumption. Second, there is a variable fee that varies with consumption but also includes transportation and distribution costs. Third, there are taxes and specific fees that vary with consumption and the specific needs of the regulator. Those customers who have not had any consumption in a given

[3] As emerges from Law No. 24.076 of May 20th, 1992 that regulates the transportation and distribution of natural gas in Argentina.

period are charged a fixed amount. Table 1 shows the tariff structure valid between 1992 and 2004.

Consumers residing in the Buenos Aires province have to pay an additional $AR0.04 for the fixed fee and $AR13.1 for the minimum bill. An almost negligible charge of $AR0.004 per cubic meter is also added to these consumers' variable fees. The billing period for residential gas consumers in the City of Buenos Aires and in the province of Buenos Aires is every two months.

In 2004, the regulator (ENARGAS) established three tariff categories (R1, R2 and R3) that would be based on the accumulated consumption of the previous 12 months. However, it also determined that tariffs across categories would remain unchanged until an agreement between the government and the distributor was reached about how to proceed with the contracts that were broken after the 2002 devaluation.[4] (See Table 2.)

In October 2008, the first increase in the residential gas tariff since 2002 took place. The three categories were replaced by eight new tariff groups. Now, the tariff schedule included different prices for the different groups of consumers. The new tariff schedule resulted in a significant increase in the variable tariff for those consumers who had had higher consumption. In particular, the R31-R32 and R33-R34 categories faced an increase of 18 and 23 percent in the price of gas per cubic meter consumed, respectively.

The fixed fees and the minimum charges for low levels of consumption remained unaltered.[5] The slight higher prices for the consumers residing in the province of Buenos Aires were also maintained. Table 3 presents the new tariff schedule with the corresponding accumulated 12-month consumption levels and variable fees for each tariff group.

As a consequence of numerous complaints from customers against the new tariff schedule, the regulator decided to implement a new adjustment to the tariff. As a consequence, variable fees were reduced by around 6.5 percent for the low previously accumulated consumption categories, but they were significantly raised for the higher consumption groups R31-32 and R33-R34 by 19.4 and 43.6 percent, respectively. Table 4 shows the resulting tariff structure.

Faced with the prospect of potential production bottlenecks and shortcuts, the regulator also decided to create a special trust fund (*Fondo Fiduciario*) to finance gas imports on

[4] See Presidential Decree 181/2004.
[5] Resolution ENARGAS I/466, retroactive to September 1, 2008.

November 27, 2008. This special fund was to be financed by an additional variable fee on residential users with higher consumption in the R32, R33 and R34 categories.[6] Table 5 presents this new variable fee for each of the affected tariff categories.

The new tariff schedule and the trust fund fee unleashed generalized protests in the middle-class neighborhoods of the city of Buenos Aires and Buenos Aires province in the winter of 2009. Amidst this increasingly hostile scenario, on June 4, 2009, the regulator decided to exempt categories R31 and R32 from the trust fund charge. The measure was effective starting in May 2009 and applied to consumption between May and August of the same year.[7]

This measure entailed that users in the R33 category faced the full increase in tariffs while consumers in the R32 faced only a partial increase. This difference in tariffs for the two groups allows us to exploit this discontinuity to identify the causal effects of the May 2009 tariff increase on the demand for residential natural gas in the greater Buenos Aires metropolitan area, as we explain in the following sections.

3. Data

We draw on administrative records from MetroGAS S.A. (the natural gas distribution company for the region). MetroGAS S.A. is one of the largest residential gas distributors in Argentina, with a client base of about 2.5 million households residing in the greater Buenos Aires metropolitan area (which has a population estimated at more than 13 million inhabitants).

Our data set includes a representative sample of almost 7200 residential consumers.[8] These consumers were selected because they belong to a narrow band of just 20 cubic meters above and below the threshold of 1,500 cubic meters of accumulated consumption that separates the categories R33 and R32. Among them, we define the group composed of consumers in the 1,501-1,520 range of annual accumulated consumption by May 2009 as the treatment group and the consumers in the 1,480-1,500 range as the control group.

The data contains detailed administrative records on bi-monthly and accumulated (past 12 months) consumption, as well as information on the composition of the residential tariffs at

[6] Presidential Decree Nº 2067/08.
[7] Resolution ENARGAS I/768.
[8] Obtaining data for a larger set of consumers was not possible due to the firm's desire to minimize the number of observations provided for confidentiality reasons.

the residential consumer level. Using information on consumption and bill payments, we constructed unit value prices effectively paid by consumers (price per cubic meter).

4. Research Design

An ideal experiment designed to estimate the impact of a price shock on residential energy consumption would randomly assign some consumers to a treatment group, facing price P_H, and other consumers to a control group, facing price P_L. Unfortunately, a large-scale experiment of this kind has yet to be implemented, making the task of estimating this behavioral response rather difficult. To approximate such an ideal experiment, we exploit unique features of the price determination mechanism for natural gas residential consumers in Buenos Aires, along with the specific information set available to consumers.

In May 2009, consumers with annual accumulated consumption of more than 1,500 m^3 were assigned a unit price roughly 25 percent higher than those that had not reached this level. This discontinuity of the unit price schedule makes it possible to apply a Regression Discontinuity Design (RDD) in which the outcome variable corresponds to the two-month consumption level and the running variable to the annual accumulated consumption.

However, as we explain in detail below, the interpretation of RD design estimates in this setting is made difficult by two important features of the price determination mechanism: i) the category to which consumers are assigned to (and hence the unit price they effectively face) is determined by the accumulated consumption of the previous 12 months; and ii) the categorization of consumers is revised every two months, in line with the variation of the 12-month accumulated consumption over that period.

4.1 The Price Determination Mechanism

Let us define the key variables underlying the determination of unit prices in a given bimonthly period *t*. The annual accumulated consumption AAC_t corresponds to the sum of the actual consumption C_t in the previous 6 bimonthly periods:

$$AAC_t = \sum_{j=t-5}^{t} C_j \qquad (1)$$

The total bill B in period *t* can be expressed as:

$$B_t = FC + VC_t * C_t + \mu_t \qquad (2)$$

where FC is the fixed cost, VC_t is the variable cost, and μ_t is an idiosyncratic shock which captures the fact that the bill received by the consumers sometimes contains idiosyncratic adjustments and retroactive charges (e.g., taxes and other charges set up by the regulator on a rather ad hoc basis).

The variable cost in a given period t is a function of whether accumulated consumption is above or below certain threshold:[9]

$$VC_t = \left\{ \begin{array}{ll} x & if\ AAC_t \geq 1500 \\ x*(1+y) & if\ AAC_t < 1500 \end{array} \right\} \quad (3)$$

Finally, while consumers may target consumption level CT_{t+1} they are unable to perfectly control their gas consumption patterns. Hence, actual consumption will differ from targeted consumption by a random shock. That is:

$$C_{t+1} = CT_{t+1} + e_{t+1} \quad (4)$$

Let us define consumers P_H as those that have an annual accumulated consumption barely above 1,500 m^3 and consumers P_L as those that are barely below the 1,500 m^3 threshold. In May 2009, consumers P_H received a gas bill with unit prices about 25 percent higher than consumers P_H. Whether or not we would expect this price shock to have a differential impact on future consumption patterns crucially depends on the specific information set held by consumers. We consider two alternative scenarios.

Scenario 1: Perfectly Informed Consumers

Let us first consider the case in which consumers have perfect knowledge about the price determination mechanism and their AAC_t. Since households are reclassified every period on the basis of their annual accumulated consumption, fully informed consumers P_H and P_L face the same expected price for period $t+1$. Hence, both groups have essentially the same incentive to restrain consumption so as not to surpass the 1,500 m^3 threshold in period $t+1$, despite the fact that the bill received in period t contained sharp differences in unit prices. Therefore, under this scenario applying a RD design that compares both sets of consumers will not estimate the short-term consumption effect of effective differences in unit prices. In effect, in this setting we would

[9] For simplicity, in this section we focus on consumers with annual accumulated consumption between 1,200 and 1,800 m^3 who can therefore face only two potential prices.

expect not to observe any significant difference between consumption levels of the two groups of consumers in period *t+1*.

Scenario 2: Imperfectly Informed Consumers

Alternatively, let us consider a setting in which consumers possess imperfect information about the prevailing price determination mechanism and do not know their AAC_t. Rather, households perceive that the total utility bill is a function of price and quantity consumed, and they infer future prices from those charged in past utility bills. That is:

$$B_t = VC_t * C_t + \mu_t \quad (5)$$

and

$$VC_{t+1} = VC_t + \rho_t \quad (6)$$

where ρ_t is an iid shock. In this setting, consumers experiencing a price shock in period *t* would face a higher perceived price and therefore have a differential incentive to restraint consumption in period *t+1*.

In light of the well-documented prominence of information imperfections in residential energy markets with ex post billing (Shin, 1985), and considering the complexity and novelty of the price determination mechanism in the Buenos Aires residential gas market, we would expect Scenario 2 to be the most plausible one. Which setting provides a better fit to reality is, however, an empirical question to which we turn in the next sub-section.

4.2 Survey Evidence on Consumers Located near the Discontinuity

To determine which of these two scenarios is valid in the present context, we administered a survey to a representative subsample of 353 households. The survey was dispensed by telephone to a randomly selected group of residential energy consumers in our sample group. The sample was stratified by district to ensure an adequate geographical representation.

The survey questionnaire consisted of two blocks of questions. The first block inquired about household socioeconomic characteristics (e.g., age, education, housing conditions, etc.). The second block included questions related to consumer's ability of consumers to understand how their monthly utility bill is calculated, which tariff group they belong to and of which fees the tariff bill consists. The latter block also inquired about whether consumers read the bill and whether they were responsive to the last tariff increase. In the following paragraphs, we present the results of the survey that are most relevant to our research. The complete set of findings is available from the authors upon request.

We have found, first, that consumers read the bill and are aware of changes in the tariff. As can be seen in Table 6, 92 percent of users stated that they remembered the amount of the last bill. In turn, 77 percent of the surveyed consumers noticed that the price of residential gas has increased in the last two years. Additionally, the percentage of people who pay their bill by automatic debit is very small (14 percent), which reduces the possibility that consumers may be not very aware of how much they pay every month.

However, knowledge about the price determination mechanism is almost non-existent. First, a sizeable majority (83 percent) of customers responded that they do not know the category to which they belong (Table 6). Among the group that responded that they did know (the remaining 17 percent), only 14 percent provided the correct answer. Therefore, only an approximate 2 percent of consumers know the category they belong. Second, 69 percent of customers state that they do not know how the price is determined (Table 6). The actual percentage may be even higher, as some of those who respond affirmatively may not actually know. Third, more than 80 percent of the customers do not know how often the tariff is recalculated (Figure 1). Fourth, the majority of customers do not know the basis of consumption the firm uses for distributing the consumers into groups and hence establishing the appropriate tariff (Figure 2). Finally, only 4 percent of those surveyed know the threshold of accumulated consumption (1,500 m^3) that is used to separate them from the other closest group of consumers (Figure 3). Overall, only 0.6 percent of consumers responded that they knew the category to which they belong, how often the tariff is recalculated, and the threshold of accumulated consumption.

Summarizing, the results from the survey indicate that consumers know how much they are paying for their consumption, but they have very scant information about the fact that they are very close to the threshold. Consequently, in the remainder of this paper, we will assume that the vast majority of consumers have imperfect information about the prevailing price determination mechanism and infer future prices from past utility bills.

4.3 Econometric Model

Under the assumption that Scenario 2 prevails (most if not all consumers have imperfect information), we can estimate the short-term effects of varying the price inferred by consumers from utility bills by applying an RD design. That is, we can compare gas consumption in period 1 for consumers that in period 0 had annual accumulated consumption barely above 1,500 m^3 with those barely below this level, as both sets of consumers should be very similar along observed and unobserved dimensions but experienced a sizable difference in unit prices. Since we can reasonably assume that consumers infer future prices using information from the last utility bill, differences in consumption in period 1 between both sets of consumers can be interpreted as the short term behavioral reaction to perceived unit price changes.

To implement the RD design we estimated the following regression model:

$$C_{i,1} = \beta_0 + \beta_1 Treatment_{i,0} + f(ACC_{i,0}) + \omega_{i,1} \qquad (7)$$

where $C_{i,1}$ corresponds to actual consumption for consumer *i* in period 1 and $ACC_{i,0}$ corresponds to consumption in period 0. The treatment variable is a dummy that indicates whether individual *i* in period 0 was assigned the higher unit price and is determined as:

$$Treatment_{i,0} = \begin{Bmatrix} 1 \ \ if\ AAC_0 \geq 1500 \\ 0\ if\ AAC_0 < 1500 \end{Bmatrix} \qquad (8)$$

There are different ways to implement the estimation of treatment effects under RD design. Imbens and Lemieux (2008) recommend the use of local linear regression in a narrow window around the discontinuity. We follow this approach and use information on all consumers that were billed in May 2009 and that had an accumulated annual consumption between 1,480 and 1,520 m^3 at that time. Period 0 is defined as that billed in May 2009, and hence period 1 corresponds to that running between May and July 2009 and billed in the latter month.

In RD design applications, researchers are often faced with a trade-off between bias and precision when deciding the width of the window used (a wider window provides greater precision but at the expense of higher bias). Given that MetroGAS S.A. has records on almost two million consumers, selecting this narrow window still delivers a substantial number of consumers (almost 7,200). Hence, in this application the role of potential bias is minimized through the adoption of a narrow window, but at the same time having a large number of observations makes it possible to identify small effects. We estimate a local linear regression by controlling for annual accumulated consumption as expressed in equation (7). Although in general it is recommended to control for the running variable to minimize the potential bias (Imbens and Lemieux, 2008), in this particular application the close relationship between the outcome and the running variable recommends following this approach.

5. Results

The basic identifying assumption of RD design is that the outcome variable would have been continuous at the assignment threshold in the absence of the treatment (Lee and Card, 2008). Albeit this assumption cannot be tested directly, we provide evidence on this issue by examining whether a number of covariates are continuous at the threshold. For clarity, we define a treatment group composed of consumers in the 1,501-1,520 m^3 of annual accumulated consumption by May 2009 and a corresponding control group for the 1,480-1,500 m^3 range. Given that a small bandwidth is used to select these two groups, differences in the running variable between them are minimal, as the average difference in this variable is only 20 cubic meters which represent only 1.3 percent of the mean (20/1,500). Hence, as a first approximation it is possible to compare average values between the treatment and control groups to inspect for evidence in favor of the identifying assumption. However, we additionally run local linear regressions to test for the existence of jumps in covariates at the threshold.

Table 7 presents results for the variables on gas consumption and issuance of bills. The results clearly indicate that in general there are negligible and not statistically differences regarding the timing of these events between the treatment and control groups.[10] A similar pattern emerges when exploring jumps in these variables by running regressions of the corresponding variables on a treatment dummy and controlling linearly by annual accumulated consumption by period 0 (reported as Adjusted Difference).

The results provide evidence that actual gas consumption is recorded every two months and hence consumption reported in the administrative records corresponds to actual consumption and not to imputations by the firm. Moreover, gas bills are issued approximately one week after the final measurement for the period and should be received by consumers approximately 10 days after a period ended, according to sources from the firm.

[10] Along the paper, we cluster standard errors by the running variable as suggested by Lee and Card (2008) for cases where this variable is discrete.

Table 8 provides further evidence on the similarity between the treatment and control groups by examining differences in the geographic distribution, consumption and bills by period, from the period -5 to 0. The geographical distribution is strikingly balanced between the treatment and control groups. However, the raw difference between both groups in terms of consumption in periods -5 to 0 and also for amount billed in period -5 to -1 are statistically significantly different in 5 out of 11 cases. This difference points to the need of controlling for annual accumulated consumption differences between both groups. When doing so, only 2 out of 11 cases remain statistically significantly different, and in those cases the magnitude of the difference is relatively small (less than 5 percent of the mean levels in both cases). Finally, the average bill for the treatment group is significantly higher than the one for the control group (92 versus 72 Argentine pesos).[11] The raw difference amounts to 20 pesos and the adjusted difference to 18 pesos or roughly 25 percent. Together the results suggest that the research design is valid in the sense that both groups are highly comparable in all dimensions, except on the amount billed in period 0.

Figures 4 to 7 depict the results presented in Tables 7 and 8. The same patterns highlighted in the tables clearly stand out from these figures: the covariates considered are smooth around the discontinuity. Importantly, Figure 7 clearly shows that the average amount billed in period 0 slightly increases given as annual accumulated consumption raises but jumps drastically when the latter crosses the 1,500 cubic meters threshold level.

It has been stressed in the RD design literature that this approach will not be suitable if agents can manipulate the running variable, implying that the condition that individuals on both sides of the discontinuity are similar is not fulfilled (McCrary, 2008; Lee and Lemieux, 2010). In the light of the survey evidence presented above, it seems unreasonable to expect that consumers can closely monitor consumption levels so as not to surpass the 1,500 cubic meters threshold. To explore this issue further, we follow McCrary (2008) and examine the density distribution of the running variable, in particular whether there is a jump in this density around the threshold. Figure 8 shows that the density is quite flat and does not seem to be any discontinuity around the threshold.

In light of the evidence confirming the validity of the research design, we now turn to the primary focus of the paper: the impact of a price shock on gas consumption in the subsequent

[11] The exchange rate was approximate 3.7 pesos per dollar during the period analyzed.

billing period. Results are presented in Table 9. In specification (1), we regress gas consumption in period 1 on a treatment dummy and controlling linearly for annual accumulated consumption. The results indicate that experiencing a price shock induces a statistically significant drop in gas consumption of 15.9 cubic meters or roughly 3.8 percent of the average gas consumption. The estimated effect is sizable if considering that, given the short time span, it is unlikely that consumers will adjust to the new price via investments in more efficient appliances or improvements in insulation. Moreover, as consumers will typically learn about the new price approximately 10 days after the beginning of the period, this gives them only 50 out of approximately 60 days to adjust to the inferred price shock.

The results from the other specifications show that these estimates are quite robust. In specifications (2) and (3), the basic model is supplemented with regional dummies and (more disaggregated) neighborhood dummies, respectively, yielding similar estimated coefficients. In specifications (4), (5) and (6) we use increasingly narrow bandwidth, thus restricting our attention to observations progressively closer to the 1,500 cubic meters threshold. Although the coefficients become less precisely estimated when restricting to observations in the 1,490 to 1,510 m^3 range, their magnitude remains virtually unchanged.

Finally, Figure 9 graphically depicts results from the main specification. There is a clear positive relationship between consumption in period 1 and annual accumulated consumption in period 0, as would be expected given that consumers with higher consumption in the past should also consume more in the future. But, most important, gas consumption seems to fall discontinuously at the 1,500 cubic meters threshold, suggesting that households react to the inferred price increase by substantially reducing consumption in the subsequent two-month period.

6. Concluding Remarks

Researchers and policymakers have long devoted considerable attention to whether and how swiftly energy consumption responds to price shocks. However, the goal of estimating the effect of price changes on energy consumption has been complicated by difficulties in constructing the equivalent to a treatment and control group with randomly assigned differential unit prices.

We have exploited unique features of the tariff schedule for natural gas in the greater Buenos Aires metropolitan region in Argentina, along with survey data on the specific information set available to consumers, to estimate the short-run effect of a change in gas prices perceived from the utility bill on residential gas consumption. The change in the tariff schedule introduced a non-linear and non-monotonic relationship between annual aggregate consumption and unit prices, thus generating an exogenous source of price variation. Drawing on administrative records on the utility bills of residential consumers, we have estimated the short-run consumption response to a price shock using an RD design whereby two-month consumption levels of households situated barely above an important tariff discontinuity are compared with those of consumers located barely below—hence focusing on a large group of relatively homogeneous consumers facing sizable differences in perceived unit prices.

Our estimates suggest show that a price increase inferred from utility bills induces a significant, sizable and rapid decline in residential energy consumption: a 25 percent increase in gas prices reduces residential consumption by 3.8 percent in the subsequent two-month period. The findings therefore offer scant support to the widely held belief among policymakers and regulators that energy demand is highly rigid, even within relatively short time horizons. This suggests that policy interventions via the price mechanism—such as price caps and subsidies—are in fact powerful instruments for influencing energy utilization patterns.

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Tables and Figures

Table 1. Tariff Structure Valid until 2004

Fixed fee	Variable fee per cubic meter	Minimum bill
7.75	0.14	13.08

Source: Law No. 24.076 of May 20th, 1992.

Table 2. Tariff Structure Valid since 2004

Category	Accumulated consumption	
	from [m3/year]	To [m3/year]
R1	-	500
R2	501	1,000
R3	1,001	---→

Source: Presidential Decree 181/2004.

Table 3. Tariff Structure Valid from September 1, 2008 Onwards

Category	Accumulated consumption (m3/year)		Variable fee per cubic meter
	From	To	
R1	-	500	0.154
R21	501	650	
R22	651	800	
R23	801	100	0.156
R31	1,001	1,250	0.165
R32	1,251	1,500	
R33	1,501	1,800	0.172
R34	1,801	---→	

Source: Resolution ENARGAS I/466 of October 10th, 2008.

Table 4. Tariff Structure from November 1st, 2008 Onwards

Category	Variable fee per cubic meter
R1	0.144
R21	
R22	
R23	0.156
R31	0.197
R32	
R33	0.247
R34	

Source: Resolution ENARGAS I/566.

Table 5. Trust Fund Special Charge (fee per cubic meter)

Category	Variable fee
R31	0.05
R32	0.135
R33	0.19
R34	0.27

Source: Resolution ENARGAS I/768.

Table 6. Tariff Structure Valid from September 1, 2008 Onwards

Question	Percentage of responses	
	Yes	No
Do you remember the amount of your last bill?	92%	8%
Have you noticed an increase in the price of residential gas in the last two years?	77%	23%
Do you know how the total amount of the bill is computed?	31%	69%
Do you know to what category you belong?	17%	83%

Source: Authors' calculations using survey data.

Table 7. Mean Dates of Consumption Measurement and Bill Issuance by Treatment Status (days normalized: December 1, 2008 = day 1)

	Control	Treatment	Difference
Date of final measurement			
Period -1	100.06	100.24	-0.18
	(0.13)	(0.13)	(0.19)
Period 0	161.76	161.93	-0.16
	(0.13)	(0.13)	(0.18)
Period 1	223.45	223.62	-0.17
	(0.13)	(0.13)	(0.19)
Date of bill issuance			
Period -1	107.06	107.31	-0.25
	(0.15)	(0.15)	(0.21)
Period 0	167.91	168.07	-0.16
	(0.13)	(0.13)	(0.19)
Days between final measurements			
Period -1 and 0	61.71	61.68	0.02
	(0.01)	(0.01)	(0.03)
Period 0 and 1	61.64	61.65	-0.01
	(0.02)	(0.02)	(0.03)
Days between final measurement and bill issuance			
Period -1	7.01	7.07	-0.06
	(0.09)	(0.07)	(0.11)
Period 0	6.15	6.14	0.01
	(0.02)	(0.03)	(0.03)

Notes: Period 0 corresponds to the bill issued in May 2009. Periods -1 and 1 corresponds to the previous and following cycles. Standard errors in parenthesis. Dates in the table are normalized so December 1st, 2008 corresponds to day 0. Day 100 = March 10th 2009. Day 162 = 11th May, 2009. Day 233 = July 12th, 2009. Day 107 = March 17th, 2009. Day 168 = May 17th, 2009. Day 254 = August 11th, 2009.

Table 8. Region of Residence, Consumption and Amount Billed by Treatment Status

	Control	Treatment	Raw Difference	Adjusted Difference
Region of residence				
Quilmes	0.171	0.172	-0.001	0.000
	(0.376)	(0.377)	(0.009)	(0.014)
Avellaneda	0.134	0.119	0.015	-0.015
	(0.341)	(0.324)	(0.008)	(0.014)
Ate. Brown	0.113	0.126	-0.012	0.005
	(0.317)	(0.331)	(0.008)	(0.011)
Flores	0.089	0.092	-0.002	0.003
	(0.286)	(0.289)	(0.007)	(0.008)
E. Echeverría	0.087	0.092	-0.005	**0.016***
	(0.282)	(0.289)	(0.007)	(0.009)
Belgrano	0.077	0.069	0.007	-0.009
	(0.266)	(0.254)	(0.006)	(0.013)
Floresta	0.066	0.061	0.005	0.001
	(0.248)	(0.238)	(0.006)	(0.010)
Devoto	0.054	0.064	-0.010	-0.005
	(0.227)	(0.244)	(0.005)	(0.011)
Norte	0.054	0.045	0.009	-0.014
	(0.227)	(0.208)	(0.005)	(0.011)
Other	0.154	0.160	-0.006	0.019
	(0.361)	(0.367)	(0.008)	(0.014)
Consumption in				
Period -5	450.914	456.378	-5.464	3.922
	(1.608)	(1.729)	(2.358)	(4.423)
Period -4	456.953	464.935	-7.982	-1.592
	(1.742)	(1.809)	(2.511)	(5.062)
Period -3	242.274	243.048	-0.774	**-7.062***
	(1.423)	(1.426)	(2.018)	(3.526)
Period -2	107.277	110.743	-3.466	2.760
	(0.931)	(1.052)	(1.401)	(2.933)
Period -1	96.448	96.001	-0.447	6.835
	(0.972)	(0.985)	(1.386)	(4.075)
Period 0	138.733	140.970	-2.237	-0.630
	(1.033)	(1.075)	(1.491)	(3.080)

Table 8., continued

Amount billed in				
	Control	**Treatment**	**Raw Difference**	**Adjusted Difference**
Period -5	100.558	101.380	-0.822	0.678
	(0.342)	(0.371)	(0.504)	(0.731)
Period -4	134.761	138.959	-4.198	3.658
	(0.809)	(0.898)	(1.206)	(3.034)
Period -3	52.004	51.406	0.598	**-2.473*** **
	(0.413)	(0.432)	(0.597)	(0.891)
Period -2	41.255	42.233	-0.978	-0.560
	(0.266)	(0.330)	(0.421)	(0.795)
Period -1	79.348	82.449	-3.101	1.299
	(0.505)	(0.518)	(0.723)	(1.816)
Period 0	72.336	91.728	-19.393	**17.96*** **
	(0.452)	(0.606)	(0.749)	(1.474)

Notes: Treatment and Control columns present means. The Raw Difference column reports mean difference between the Treatment and Control groups. The Adjusted Difference column presents the coefficient of regressing the respective variable on a dummy for treatment and a linear term for annual accumulated consumption in period 0. Standard errors clustered by accumulated consumption in period 0. In all cases standard errors are presented in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Other includes Almagro, Mataderos, Centro, Lomas de Zamora, Barracas, Lanús, San Vicente and Berazategui

Table 9. Impacts of Price Increase on Consumption in Period 1

	(1)	(2)	(3)	(4)	(5)	(5)	(6)	(7)	(8)	(9)
Treatment	**-15.901****	**-16.919****	**-17.415*****	**-16.296***	**-18.00****	**-18.863***	**-20.63***	**-16.091**	1113	912.5
	(6.491)	**(6.397)**	**(6.342)**	**(8.105)**	(7.922)	**(10.39)**	(9.967)	**(13.53)**	(-739.4)	(-795.7)
ACC_0	**0.720****	**0.777*****	**0.822*****	0.759	**0.876***	1.060	1.182	0.703	**1.169*****	**1.004****
	(0.290)	(0.279)	(0.272)	(0.451)	(0.450)	(0.832)	(0.808)	(1.774)	(-0.368)	(-0.412)
ACC_0 * Treatment									-0.753	-0.619
									(-0.493)	(-0.531)
Region controls	N	Y	Y	N	Y	N	Y	N	Y	N
Neighborhood controls	N	N	Y	N	Y	N	Y	N	Y	N
N	7190	7190	7190	5417	5417	3679	3679	1946	7190	7190
R-squared	0.001	0.029	0.056	0.001	0.057	0.001	0.060	0.002	0.056	0.001

Notes: The dependent variable is consumption in period 1. Average of the dependent variable is 425.49. The estimation method is OLS. In columns (1) to (3) all clients with annual accumulated consumption in a bandwidth of 20 from the discontinuity point are included (i.e. 1480-1520). In columns (4), (5) and (6) the sample includes clients in bandwidths of 15, 10 and 5, respectively. *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered by accumulated consumption in period 0.

Figure 1. Survey Results: How Often Does the Company Recategorize Consumers' Tariffs?

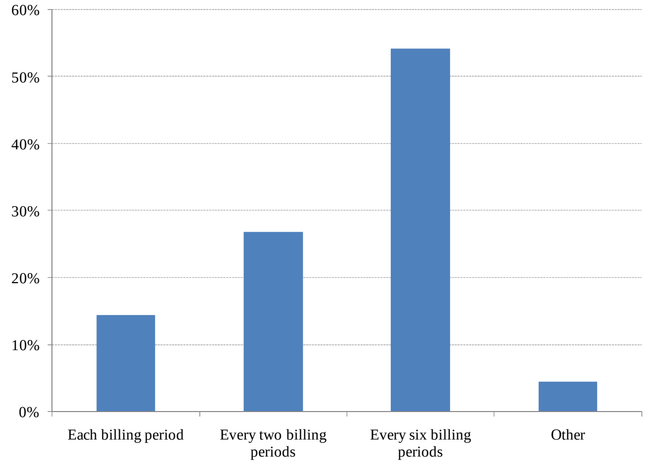
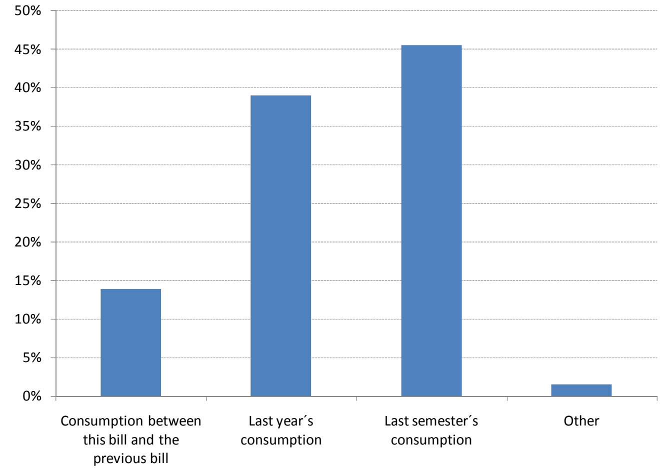


Figure 2. Survey Results: The Tariff is Calculated Based On



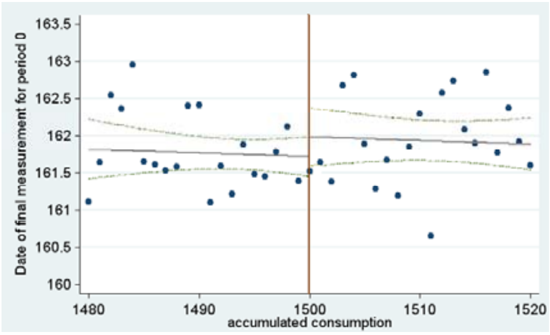
Source: Authors' calculations using survey data.

Figure 3. Survey Results: Which is the Level of Consumption that Determines a Change in your Tariff Categorization?

Source: Authors' calculations using survey data.

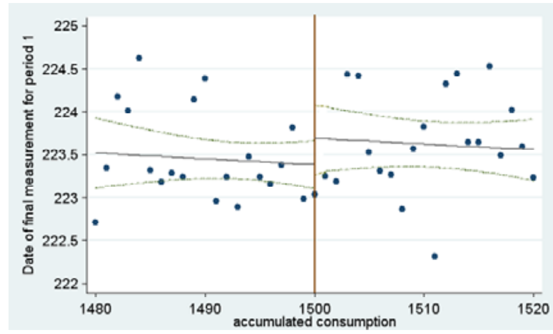
Figure 4. Dates by Annual Accumulated Consumption

Date of final measurement for period 0



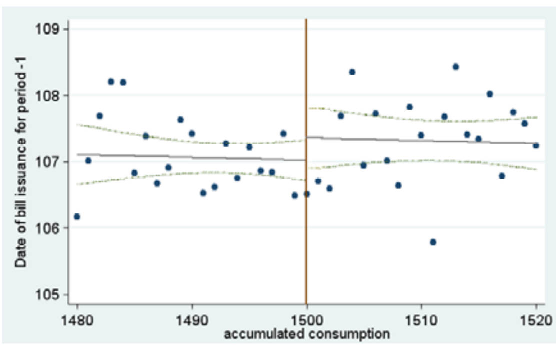
Dates in the figure are normalized so December 1st, 2008 corresponds to day 0. Day 162 corresponds to 11th May, 2009

Date of final measurement for period 1



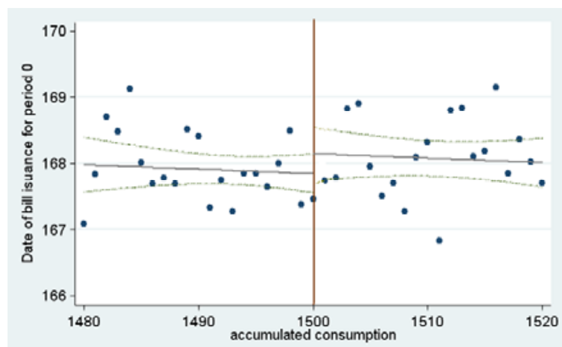
Dates in the figure are normalized so December 1st, 2008 corresponds to day 0. Day 223 corresponds to 12th July,2009

Date of bill issuance for period -1



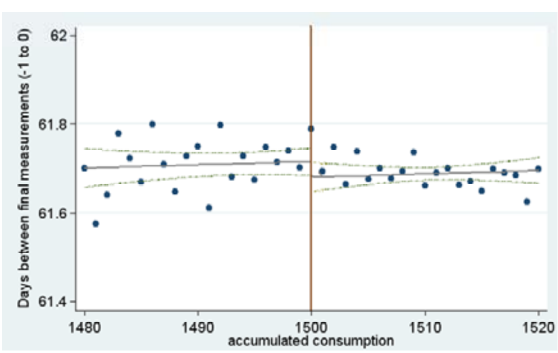
Dates in the figure are normalized so December 1st, 2008 corresponds to day 0. Day107 corresponds to 17th March,2009

Date of bill issuance for period 0



Dates in the figure are normalized so December 1st, 2008 corresponds to day 0. Day107 corresponds to 17th May,2009

Days between final measurements (-1 to 0)



Days between final measurements (0 to 1)

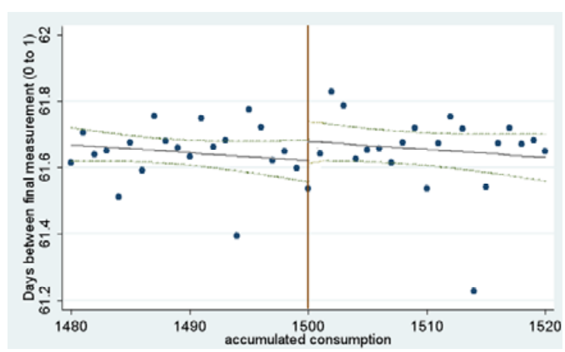
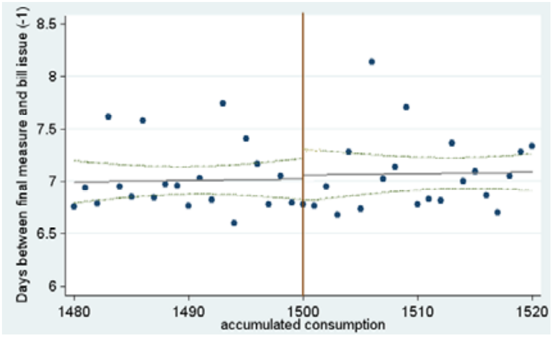


Figure 4., continued

Days between final measurement and bill issuance for Period -1



Days between final measurement and bill issuance for Period 0

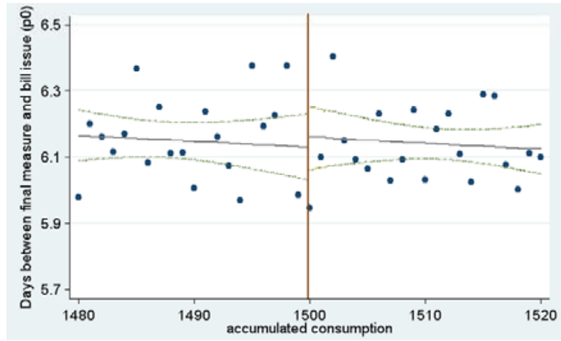
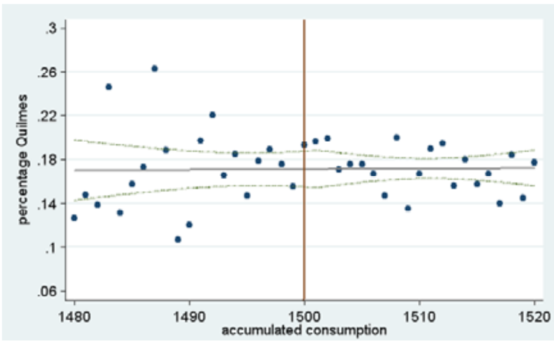
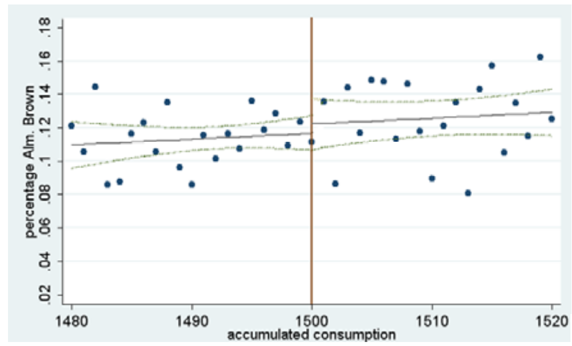


Figure 5. Region of Residence by Annual Accumulated Consumption
(by six largest regions in terms of quantity of users)

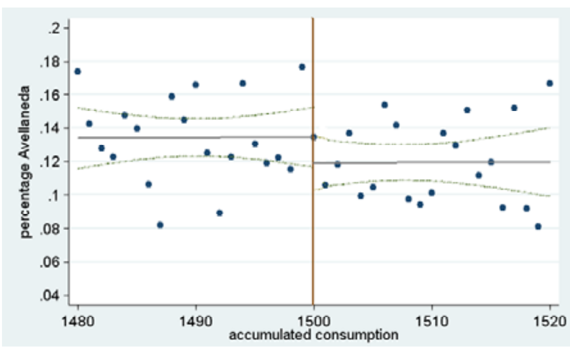
Quilmes



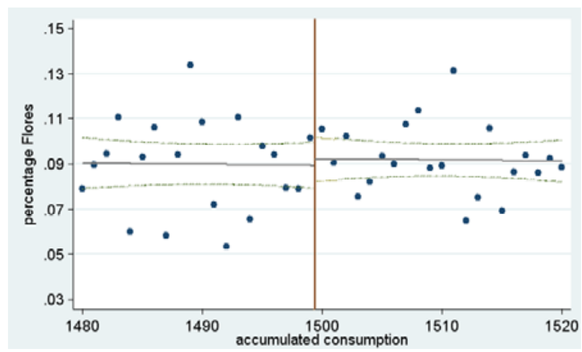
Almirante Brown



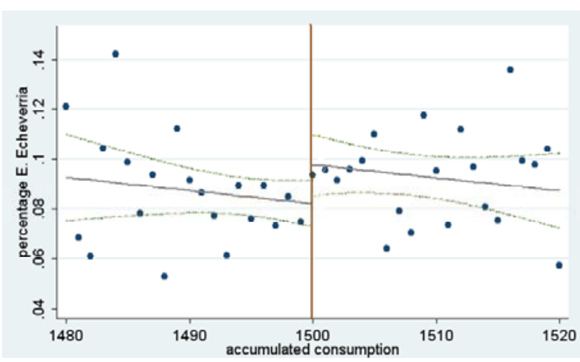
Avellaneda



Flores



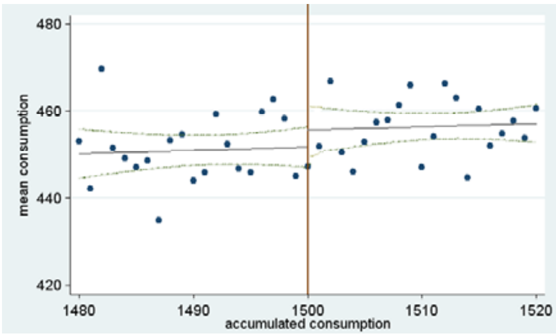
Esteban Echeverría



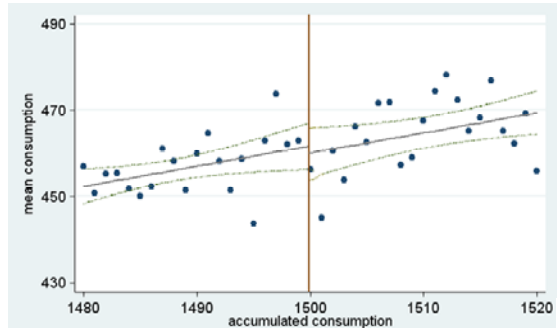
Flores

Figure 6. Average Consumption by Annual Accumulated Consumption (by period)

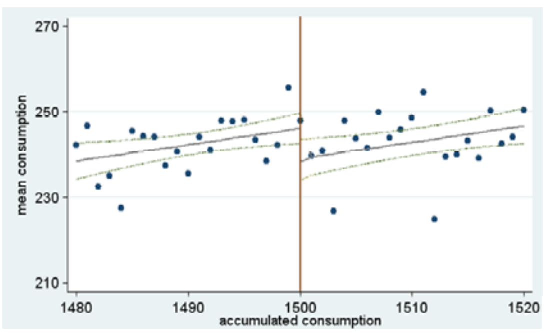
Period -5



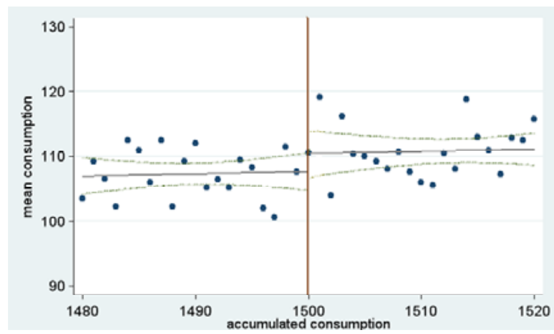
Period -4



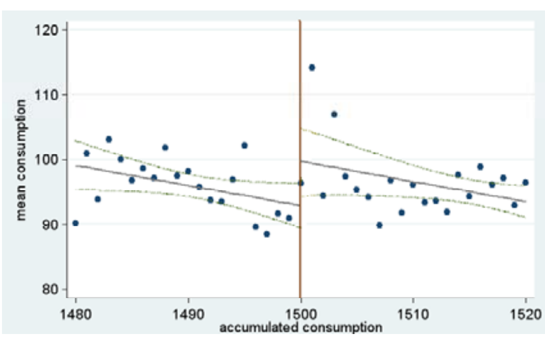
Period -3



Period -2



Period -1



Period 0

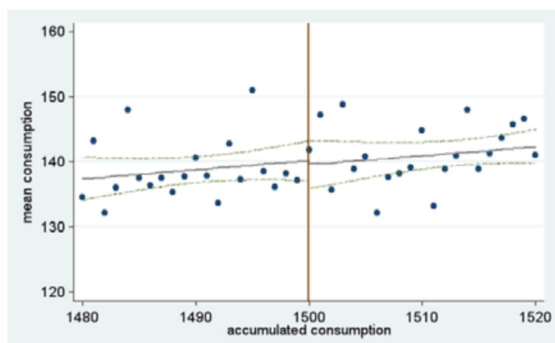
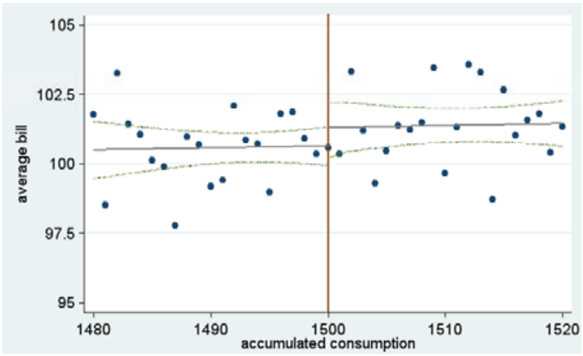
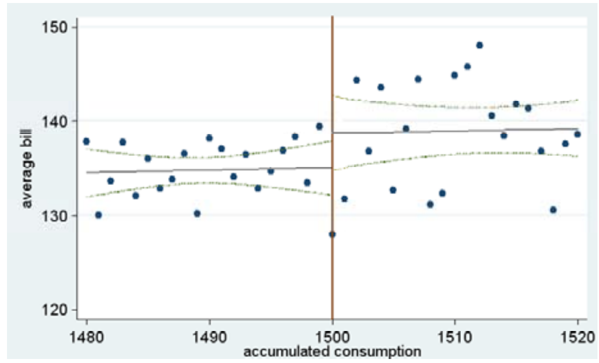


Figure 7. Average Bill by Annual Accumulated Consumption (by period)

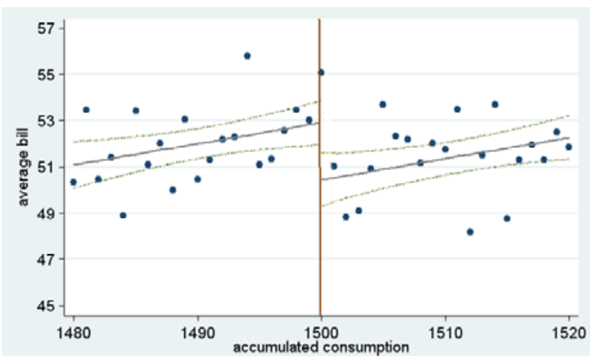
Period -5



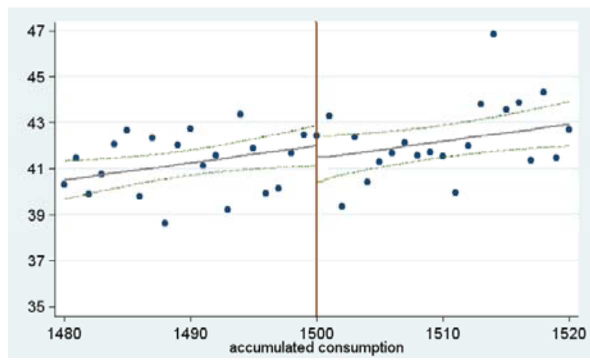
Period -4



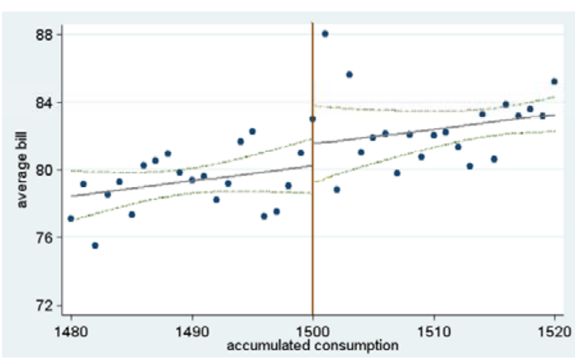
Period -3



Period -2



Period -1



Period 0

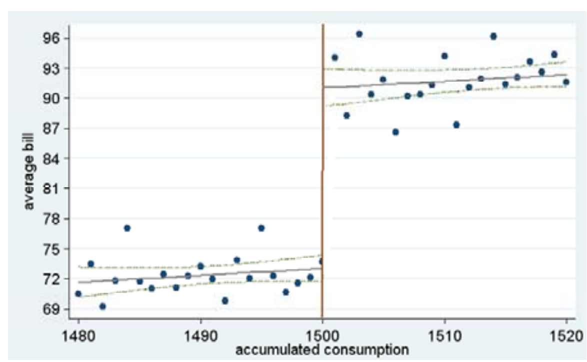


Figure 8. Number of Observations by Annual Accumulated Consumption in Period 0

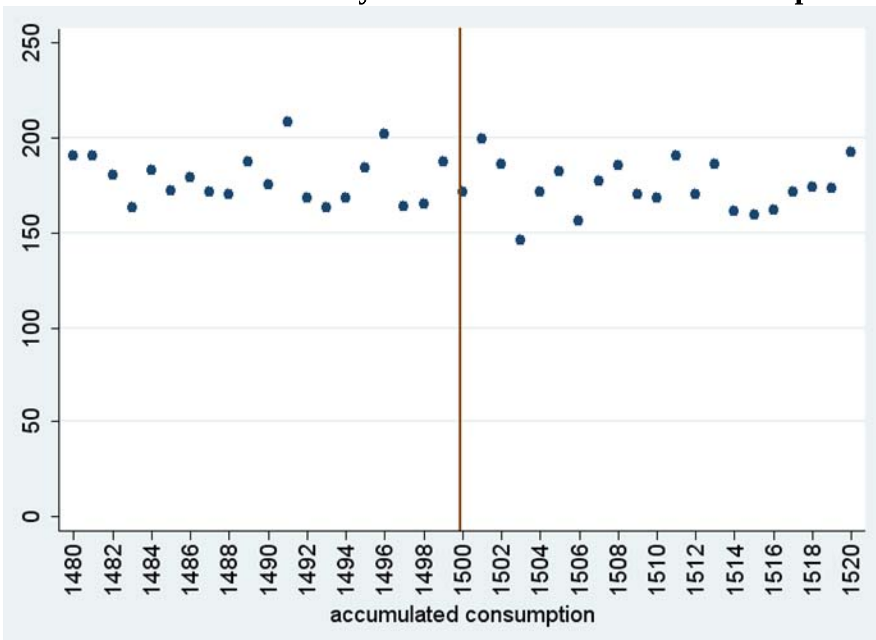


Figure 9. Average Consumption in Period 1 by Annual Accumulated Consumption