5-1-2017

"No Shut-off" Policies and Natural Gas Consumption

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Abstract: Many U.S. states have regulations that prevent natural gas utility companies from turning off service to non-paying consumers. The goal of these policies, termed "no shut-off" (NSO) regulations, is to provide a guaranteed minimum level of residential comfort by reducing the marginal cost of consumption to zero for a period of time. This paper employs a difference-in-difference approach applied to residential U.S. Energy Information Administration data to evaluate whether NSO policies generate higher levels of gas usage. Our preferred specifications suggest that activation of a NSO policy increases natural gas consumption by between 4.7–4.8%, resulting in a total increase of between 66 and 67 billion cubic feet of

[Resource and Energy Economics, Vol 48, (May 2017): pg. 19-29. DOI.

natural gas consumed per winter season in covered states, at a value of as much as $950–970 million annually.

Keywords: Natural gas usage**,** Utility regulation

1. Introduction

Nearly all U.S. states have regulations preventing utility companies from disconnecting customers' natural gas (used for home heating). While the specifics of these regulations differ, they are primarily designed to prevent gas providers from ceasing service to non-paying customers. The goal of these policies, termed "no shut-off" (NSO) regulations, is to provide the less fortunate with habitable housing when circumstances may otherwise prevent such a transaction; however; NSO policies achieve this goal by artificially reducing the marginal cost of consuming natural gas, which may result in inefficient levels of consumption relative to facing full market prices.[1] Despite nearly every state in the U.S employing some type of NSO regulation, there has been no previous evaluation of their effect on natural gas markets. This paper is the first to combine documentation of these policies with consumption data and examine the extent that residential natural gas consumption changes in the presence of NSO policies.

Our estimation strategy is to use policies that are enforced under a date-based mandate, or that become active in a given state between set calendar dates, regardless of local weather conditions. We highlight date-based policies as a way to avoid endogeneity in estimation. We use two difference-in-difference type estimation strategies to test whether average consumption increases when a NSO policy is active. The first identification strategy uses two-way fixed effects (state and month/year) and the timing of NSO policy activation to measure the effects on consumption. The second uses a standard difference-in-difference model, estimating the effect of turning the policy on for the treated group during the treated time period relative to the baseline difference between the group of NSO states and other states during non-treated times. We implement both strategies controlling for a set of covariates (weather, prices, local median income, and year effects). In addition to our general model, we

explore parallel models for variants of NSO policies, and an alternative model based on a trimmed sample using a propensity score.

Our results strongly support the idea that NSO policies lead to higher levels of natural gas consumption. Our preferred specifications suggest that activation of a NSO policy increases natural gas consumption by between 4.7–4.8%, resulting in a total increase of between 66 and 67 billion cubic feet of natural gas consumed per winter season in covered states, at a value of as much as $950–970 million annually. We also find different effects across the heterogeneous NSO policy types that have different coverage requirements. In specifications that expand the set of controls to include region-month-year effects, we estimate NSO polices increase consumption by between 2.6–3.2%, for an annual increased expense of between $530–$650 million dollars. Surveys of natural gas customer accounts show that approximately 24% of customers have account balances that are past due, implying an increase in consumption among this group of as much as 24.6%.

Our results complement estimates from Levinson and Niemann (2004) that demonstrate tenants living in utility-included rental housing (where the marginal cost of energy use is essentially zero) set their thermostats between 1 °F and 3 °F warmer in winter months. Levinson and Niemann generally find smaller magnitude increases in energy use than we do here, but they also point out that their work may provide an underestimate. Our work also represents a new contribution to explaining the "energy paradox", where consumers are seemingly too slow to adopt conservation technology.[2] If NSO policies are excusing customers from paying the full cost of natural gas usage, they have less incentive to adopt conservation technologies.

The rest of the paper proceeds as follows: Section 2 describes NSO policies and outlines our identification strategy. Section 3 describes our data and offers summary statistics. Section 4 presents results, and the final section concludes with policy discussion and directions for future research.

2. NSO policies and empirical methodology

Regulations that govern and restrict utility companies' ability to disconnect service to non-paying customers are generated at the state level. Specific details of NSO policies vary from state to state in both existence and terms, but the main components of the policies are consistent. Most states with such polices prevent or delay gas disconnection for medically-vulnerable customers year-round. In addition, many states have some type of seasonal or weather-based policy that protects customers during certain times of year or during extreme cold or heat. This paper focuses on protections that affect natural gas utilities.[3] We use the term "no-shut-off policy" to refer specifically to seasonally implemented policies throughout the paper.[4]

This paper focuses specifically on policies that are activated by dates, not weather events, and are in effect for certain months during the year, regardless of actual weather patterns. Some state NSO policies are triggered only by temperature; for example, in Oklahoma gas cannot be turned off when the actual or predicted temperature is below 32 °F during the day or 20 °F at night. Since temperature-based policies are endogenous to consumption, because consumption increases when temperature decreases, they do not make a good natural experiment to examine how customers react to these laws. Date-based policies, on the other hand, go into effect regardless of weather patterns, and promise the same protections for non-paying customers.

Summary statistics from the Natural Regulatory Research Institute (NRRI) reveal that NSO policies potentially cover a substantial segment of natural gas consumers. A NRRI report from 2005 surveyed utility providers to determine the state of consumer accounts. The findings in the report show that the percentage of customers with a balance due 30 days or older ranged from 34.3% in California to 9.84% in Colorado, with an average of 24% across the sample. Furthermore, the NRRI report finds that on average only 4.5% of customers have service disconnected, leaving a substantial share of customers that are not paying natural gas bills and still receiving service, and would thus be covered by the date-based NSO policies we examine.[5]

Table 1 shows a summary of date-based state NSO Policies. Besides the timeframe in which the policies are effective, policies also

differ by state according to which group or groups of customers are covered by the policy. Some policies apply to all natural gas customers while others only protect certain subsets of customers, such as the elderly, the disabled, unemployed customers, those whose income is below a given threshold, or households qualifying for welfare programs. We include a sub-group analysis that examines policies with varying degrees of generosity.

Table 1. No shut off policy summary.

State	Date Based	Other Plan	Type of Date Based	Active Months
AL	No	Temperature	–	–
AR	Yes	Temperature	Need Based	Nov–March
AZ	No	Temperature	–	–
CA	No	Physician Rec	–	–
CO	No	Physician Rec	–	–
CT	Yes	–	Need Based	Nov–April
DE	Yes	Temperature	Covers All	Nov–March
FL	No	–	–	–
GA	Yes	Temperature	Payment Plan	Nov–March
IA	Yes	Temperature	Need Based	Nov–March
ID	Yes	–	Vulnerable, Need Based	Nov–March
IL	Yes	Temperature	Need Based	Dec–March
IN	Yes	–	Need Based	Dec–March
KS	Yes	Temperature	Need Based	Nov–March
KY	No	–	–	–
LA	No	–	–	–
MA	Yes	–	Need Based	Nov–March
MD	Yes	Temperature	Vulnerable, Max Due	Nov–March
ME	Yes	–	Need Based	Nov–April
MI	Yes	–	Vulnerable, Need Based	Nov–March

State	Date Based	Other Plan	Type of Date Based	Active Months
MN	Yes	–	Need Based, Payment Plan	Oct–April
MO	Yes	Temperature	Need Based	Nov–March
MS	Yes	–	Need Based	Dec–March
MT	Yes	Temperature	Vulnerable, Need Based	Nov–March
NC	Yes	–	Vulnerable, Need Based	Nov–March
ND	No	Payment Plan	–	–
NE	Yes	–	Need Based, Payment Plan	Nov–March
NH	Yes	–	Vulnerable, Need Based, Max Due	Nov–March
NJ	Yes	–	Vulnerable, Need Based	Nov–March
NM	Yes	–	Need Based	Nov–March
NV	No	Temperature	–	–
NY	Yes	–	Vulnerable	Nov–April
OH	Yes	–	Payment Plan	Nov–April
OK	No	Temperature	–	–
OR	No	Physician Rec	–	–
PA	Yes	–	Need Based	Dec–March
RI	Yes	–	Vulnerable, Max Due	Nov–April
SC	No	Temperature	–	–
SD	Yes	Physician Rec	Covers All	Nov–March
TN	No	Physician Rec	–	–
TX	No	Temperature	–	–
UT	Yes	–	Vulnerable, Need Based	Nov–March
VA	No	Physician Rec	–	–

State	Date Based	Other Plan	Type of Date Based	Active Months
VT	Yes	Temperature	Vulnerable	Nov–March
WA	Yes	–	Need Based	Nov–March
WI	Yes	Temperature	Vulnerable, Need Based	Nov–April
WV	Yes	–	Need Based	Dec–Feb
WY	Yes	Temperature	Vulnerable, Need Based	Nov–April

Notes: The "other plan" column details what other types of NSO policies exist in a state (if any). Temperature indicates that the state has a temperature based no shut off policy, Physician Recommend indicates that it has a no shut off policy based on the medical recommendation of a physician, Payment Plan indicates the state has a no shut off policy that allows customer to be placed on a payment plan.

Need Based indicates a date based policy that is active for customers with demonstrated financial hardship, unemployment, recipients of government welfare, etc.

Vulnerable indicates a date based policy that is active for customers with illness, disability, and/or elderly or very young customers.

Max Due indicates a date based policy that is active for customers whose outstanding bill is under a certain dollar amount.

Payment Plan indicates a date based policy that is active for customers who commit to a payment plan to pay their outstanding bill.

Covers All indicates a date based policy that covers all customers, regardless of characteristics.

We do not have data on policies for Alaska, Hawaii, and Washington, D.C., these areas are excluded from the analysis. NSO policy data are summarized from the following sources: Howat and Devanthary (2006); Harak and Wein (2008); Harak et al. (2011); LIHEAP Clearinghouse (2013).

In all, 33 states have some type of date-based NSO policy. Many of these states are Midwest and Northeastern states, but there are also several Western and Southern States that have policies. Of the states that have a date-based policy, the most common is a "Need Based" policy, or one that covers only a population that has some demonstrated financial hardship. Some states combine a need-based criterion with a "Vulnerable" criteria, which makes the NSO policy conditional on customer personal characteristics such as being disabled, ill, or elderly. Other variants of date-based policies are those that only cover customers who have an outstanding balance under a certain dollar amount ("Max Due"), or those that agree to be put on a payment plan ("Payment Plan"). There is also a set of states (DE and SD) that enforce a date-based NSO policy for all natural gas customers ("Covers All"). The second column also shows information on states that have a separate policy covering customers based on temperature or on the advice of a physician.

To isolate the effect of NSO policies on natural gas consumption, it is necessary to separate the policy's effect from all other factors that influence consumption. Any characteristics common to those states that have NSO policies, as well as factors common to the months in which the policies are active must be accounted for. There could be an unknown or unquantifiable factor or factors influencing consumption of natural gas in the states that have NSO policies. Similarly, the months during which policies are typically active could have more in common with each other than what is captured by weather variables. It is impossible to identify and measure all the characteristics common to each group of states or months, but to ignore their influence would certainly result in omitted-variable bias.

We offer two estimation strategies to deal with omitted variables, both use the timing of NSO policies becoming active for certain months to identify the effect of the policy. The two strategies we implement are a two-way fixed effects model and a standard difference-in-difference model. The difference between the models is how they control for cross section variation and seasonal/time variation. The two-way fixed effects model accounts for any time-invariant characteristics at the *individual* state level, while the standard difference-in-difference approach accounts for any time-invariant characteristics among the *group* of states that choose to

have NSO policies. The two-way fixed effects model accounts for any time-varying or seasonal characteristics at the month-year level, while the standard difference-in-difference approach accounts for any time varying characteristics among the group of covered months only.

The two-way fixed effects model is:

(1)

Where the dependent variable *F* is the statewide monthly flow of natural gas consumption per resident. The subscripts *i*, *t*, and *m* refer to the state, year, and month, respectively. The variable *NSOActive* is equal to one for the NSO states in the months when a policy is active, and zero otherwise.[6]

The inclusion of state and month-year fixed effects will control for any permanent differences between states, and for any differences that are common to all states, but change with time or seasonality. State fixed effects, δ_i, are important if there are constant factors within each state that drive gas usage and are correlated with when policies become active (for example a state being situated in a particular part of the country). Month-year effects, $\gamma_{m,t}$, are important if there are constant factors across months of the season and or years of the data that are correlated with natural gas consumption and when policies become active (for example, policies generally being active during peak heating seasons). The coefficient of interest in Eq. (1) is β_1, which identifies the effect of an active NSO policy on residential consumption of natural gas.

To account for other factors that affect gas consumption per person that may vary by state and month/year, we add various control variables to the base model in *X*. Importantly, we condition our estimates on differences in temperature changes through the variable Heating Degree Days. We also condition on the residential price of natural gas, and the local median income of residents (in thousands). The Heating Degree Days variable is expected to have a positive effect on gas consumption, since the lower the temperature, the greater number of heating degree days there are, and the more gas is needed to heat homes.

As an additional guard against unobserved heterogeneity that may vary by time/season but be specific to particular regions, we estimate (1) replacing $\gamma_{m,t}$ with a set of region-specific month-year effects, $\sigma_r * \gamma_{m,t}$. We present results with the region specific month-year effects alongside of the standard two-way fixed effects results for comparison purposes.

We also estimate a standard difference-in-difference model, which allows us to estimate whether average consumption of natural gas increases with an active NSO policy, relative to states without an active policy for months the policies are typically active. This model is a more basic version of (1), with less stringent controls for time-invariant and time-variant effects that may be correlated with when NSO policies become active. The difference-in-difference model tests whether the difference between average consumption in states with a NSO policy, and average consumption in states without a policy, shifts when a policy becomes active. It answers the question of whether states with an active policy consume more gas than they would have without an active policy, by looking for a change in the difference in consumption between states with and without a policy as a group.

The difference-in-difference specification is:

(2)

Where *NSO State* is a dummy variable equal to one if a state has an NSO policy and zero if it does not. *Month Covered* is a dummy variable equal to one if the calendar month is between October and April, inclusive, and zero otherwise.[7] The model identifies all states with NSO policies and all months covered by NSO policies, and the interaction of being a NSO state during a month that is covered. *NSO Active* is similar, but not equal to, the interaction between *NSO State* and *Month Covered* because the months in which a policy is active differ by state, and *Month Covered* includes all months in which *any state* has an active policy. *Month Covered* controls for characteristics common to the months in which no-shut-off policies are active, but is only a coarse replacement for the month-year effects in (1). The coefficient of interest is β_3, which tells us the marginal effect of activating an NSO policy on monthly gas usage. All control variables in this model are the same as the state fixed-effects model, and the model identifies the effect of the NSO policies when they become active within a given

state during the month specified by law. We also estimate a version of (2) that replaces *Month Covered* with a month-year fixed effect. We cluster all standard errors in both specifications at the state level.

2.1. Policy heterogeneity

In addition to estimating (1) and (2) to determine the general effects of NSO policies, examining variations in the specific rules of the policies may show what aspects of the policies matter most for moral hazard. Most NSO policies only apply to certain subsets of customers, such as the medically vulnerable or those with financial hardship. To determine the different impact of the various policy types, *k,* we estimate the following two-way fixed effect and difference-in-difference specifications:

(3)
and
(4)
Where the *k* different policy types are described in Table 1. We separately estimate the effect of Need Based, Vulnerable, Payment Plan, and Covers All policies. We do not separately estimate for the Max Due category, as it is never mutually exclusive for a state, but note that it is tied to other policies in some states, and we cannot rule out the effect of Max Due policies from other categories. These regressions use states with other NSO policies as the reference group, so the interpretation is the marginal effect of altering the NSO policy relative to the average of all other NSO policies.

3. Data

The data on no shut-off policies come from the National Consumer Law Center (NCLC) and the Low Income Home Energy Assistance Program (LIHEAP). The NCLC published summary tables of extreme weather protection rules in 2008 and 2011, while LIHEAP maintains a current list of no-shut-off policies and provided such a table for a study published in 2006.[8] Together, these tables provide policy data for the 48 contiguous United States from the beginning of 2006 through February of 2013. To fill in the missing years for which there are no summary tables, we make the following assumptions. If a

policy does not change in two subsequent tables, it is assumed that the policy does not change over that period. For example, if a state has the same policy in 2011 as it did in 2008, we assume that the same policy was also in place in 2009 and 2010. Since there are very few differences among the summary tables, this assumption seems reasonable. Where differences do occur among the tables, state regulations and utility company documents are assembled to pinpoint the nature and effective date of the policy change. Although there are several differences between the tables, most of these are due to different methods of recording the policies rather than actual substantive changes to the policies. There are no substantial changes in the date-based cold weather protections between 2006 and 2013.

The dependent variable, natural gas flow per resident, is the total statewide monthly gas consumption by residential consumers divided by the state population. Natural gas flow data are obtained from the United States Energy Information Administration (EIA) and are measured in millions of cubic feet. The American Gas Association estimates that an average American house consumes 250 cubic feet of gas per winter day. State level population data is gathered from the census, and linearly interpolated between annual estimates to apply monthly.

Weather is the single most important driver of natural gas consumption, and it is also the most important factor determining when non-date-based NSO policies are active. Heating degree days measures the monthly sum of how many degrees the average daily temperature is below 65°. For example, if the average temperature is 35 °F one day (30° below 65°), and 60 °F the next day (5° below 65°), the total heating degree days for these two days is 35. Heating degree days are preferable to average monthly temperature because they capture the variance of temperatures within each state-month, rather than just the mean temperature. All heating degree day data (measured in degrees Fahrenheit) are obtained from the National Oceanic and Atmospheric Administration, which is part of the United States Department of Commerce.

Natural gas prices vary by state and time of year and affect consumption, so we include them as a control variable. The price data are obtained from the EIA, the same source as the natural gas flow

data. The EIA data are given in nominal dollars per thousand cubic feet of gas.[9] We also use median income as a control variable to account for time trends and potential seasonal adjustment to consumer incomes that may coincide with policy activation.[10]

4. Results

Our primary results, shown in Tables 2 and 3 reveal that activating an NSO policy has a large, positive, and statistically significant effect on natural gas consumption across both state fixed effects and difference-in-difference models. These effects remain strong in the presence of estimating with control variables and adding year effects to the model. The magnitude of the NSO policy effect depends on the method and specification employed, with extremely large estimates in specifications that do not control for local weather conditions, and more modest estimates in specifications that control for weather.

4.1. State fixed-effects results

Table 2 shows the results for estimating Eq. (1), using a variety of control variables. These results show that an active NSO policy has a large, positive, and statistically significant effect on natural gas consumption. The largest estimates, those without controls for Heating Degree Days, show that activation of an NSO policy causes a 10.9–19% increase in natural gas use. The magnitude of results that do not control for weather demonstrate omitted variable bias, as Heating Degree Days certainly contribute to natural gas usage, and is also likely correlated with when NSO policies become active. We take these results as a caution on the importance of controlling for weather, even when using date-based policy implementation to identify the effects of NSO policies on consumption.

Table 2. Natural gas consumption and NSO Policies: two-way FE estimates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NSO Active	0.190***	0.048***	0.047**	0.047**	0.109***	0.032***	0.026**	0.026**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.013)	(0.013)	(0.011)	(0.011)	(0.012)	(0.011)	(0.010)	(0.010)
Heating Degree Days		0.001***	0.001***	0.001***		0.001***	0.001***	0.001***
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Retail Price			−0.053***	−0.053***			−0.041***	−0.041***
			(0.001)	(0.001)			(0.001)	(0.001)
Median Income (thousands)				−0.001				0.002
				(0.002)				(0.001)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year Effects	Yes	Yes	Yes	Yes	No	No	No	No
Region × Month × Year Effects	No	No	No	No	Yes	Yes	Yes	Yes
N	4128	4128	4128	4128	4128	4128	4128	4128
R-Squared	0.962	0.968	0.976	0.976	0.977	0.982	0.985	0.985

The dependent variable in all regressions is the natural log of monthly natural gas consumption (millions of cubic feet) per capita. NSO Active represents the interaction between a state with an NSO policy and a month when the policy is active for date-based NSO policies only. Months that are partially covered by NSO policies are considered fully covered in the data. The unit of observation is a state-month. Standard errors clustered at State level are shown in parentheses.

***

$p < 0.01$.

Controlling for Heating Degree Days reduces the magnitude of the results considerably. In the base two-way fixed effects specifications that control for Heating Degree Days, our estimates suggest that activation of an NSO policy increases natural gas consumption by between 4.7–4.8%. These results are statistically significant at the 1% level regardless of the set of control variables we use. At a state-month average level of consumption of 8193 millions of cubic feet, these results suggest NSO policies cause an increase of 385–393 million cubic feet per state, per month. With 33 state policies in place, at an average coverage length of 5.2 months, NSO policies cause a total increase in natural gas consumption of 66–67 billion cubic feet per winter season. Given the average retail price of $14.40 per thousand cubic feet, active NSO policies cause between $950–970 million dollars annually in increased expense.[11]

In specifications with *Region* * *Month*/*Year* effects, shown in columns 5–8 of Table 2, the magnitude of our estimates is smaller than the two-way fixed effects estimates, but still positive and statistically meaningful. These estimates, when controlling for Heating Degree Days and a variety of other time-variant factors show that NSO policies increase natural gas consumption by between 2.6–3.2%. At a state-month average level of consumption of 8193 millions of cubic feet, our most conservative results represent an increase of 213–262 million cubic feet per state, per month for a total increase in natural gas consumption of 36–44 billion cubic feet per winter season. The smaller magnitude estimates imply an annual increased expense of between $530–$650 million dollars.

To put the magnitude of these estimates in further context, consider that the most recent provider survey of natural gas customer accounts shows 24% of customers have account balances that are past due, but only 4.5% have service disconnected (National Regulatory Research Institute, 2005). If average consumption is constant across customer account types and there is no behavioral response from customers who are not past due or already disconnected, our estimates imply that to get to a total increase of

between 2.6 and 4.8% (the range of estimates from our results that control for Heating Degree Days in Table 2), customers actually covered by NSO increase consumption by between 13 and 24.6%. If we count current disconnected customers as being affected by the policy, our estimates imply that covered customers increase consumption by between 10.8 and 20%.

4.2. Difference-in-difference results

Table 3 shows the results of estimating Eq. (2), or our standard difference-in-difference specification. As with the two-way fixed effects model, these results rely on the date an NSO policy becomes active being exogenous, and uncorrelated with omitted factors that drive natural gas usage. The difference between this model and the two-way fixed effects models, is that this specification only controls for common cross-section characteristics for the grouping of states that have a date-based NSO policy rather than for characteristics of individual states and only controls for time-variant factors that are common among months when policies are active (with the exception of estimates that use month-year effects in columns (5) and (10)).

Table 3. Natural gas consumption and NSO policies: difference-in-difference estimates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NSO State	0.040	0.090	0.100	0.091	0.206	0.046	0.092	0.101	0.090	0.178
	(0.231)	(0.206)	(0.162)	(0.159)	(0.137)	(0.231)	(0.206)	(0.158)	(0.156)	(0.141)
Month Covered	1.016***	0.448***	0.290***	0.311***	–	1.011***	0.448***	0.277***	0.304***	–
	(0.066)	(0.110)	(0.099)	(0.099)		(0.065)	(0.111)	(0.099)	(0.099)	
NSO Active	0.759***	0.079	0.193**	0.207**	0.092	0.747***	0.077	0.219**	0.237***	0.129*
	(0.073)	(0.121)	(0.087)	(0.086)	(0.064)	(0.074)	(0.122)	(0.084)	(0.084)	(0.072)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Heating Degree Days		0.001***	0.001***	0.001***	0.001***		0.001***	0.001***	0.001***	0.001***
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
Retail Price			−0.096***	−0.097***	−0.111***			−0.109***	−0.110***	−0.111***
			(0.020)	(0.020)	(0.024)			(0.022)	(0.022)	(0.024)
Median Income (thousands)				0.007	0.012				0.009	0.012
				(0.008)	(0.009)				(0.008)	(0.009)
Year Dummies	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Month-Year Effects	No	No	No	No	Yes	No	No	No	No	Yes
N	4128	4128	4128	4128	4128	4128	4128	4128	4128	4128
R-Squared	0.476	0.585	0.681	0.684	0.684	0.480	0.586	0.697	0.701	0.720

The dependent variable in all regressions is the natural log of monthly natural gas consumption (millions of cubic feet) per capita. NSO State represents a dummy variable indicating a state that has a date-based NSO policy. Month covered represents a dummy variable for months when NSO policies are active. NSO Active represents the interaction between a state with an NSO policy and a month when the policy is active for date-based NSO policies only. Months that are partially covered by NSO policies are considered fully covered in the data. The unit of observation is a state-month. For results in column

(10) a month for each year is omitted from the specificaion due to colinearity. Standard errors clustered at State level are shown in parentheses.

**

$p < 0.05$.

*

$p < 0.1$.

The results in Table 3 generally show substantially larger effects of NSO policies on natural gas usage than the state fixed-effects model. The most conservative estimates, which control for heating degree days, but not prices or income, suggest a 7.7–7.9% increase in natural gas usage, although these specifications do not produce a statistically meaningful result. Across specifications that implement control variables, we find the effect of an active NSO policy causes between a 19.3 and 23.7% increase in natural gas usage, statistically precise at either the five or one-percent level in all specifications, except when estimating with month-year effects.

One explanation for why the difference-in-difference results are larger than the state fixed effects results is that there is unobserved heterogeneity within the group of states that have NSO policies. This is picked up by the state fixed-effects models, but not the difference-in-difference models because those states are treated as a group. Part of this heterogeneity is the difference in NSO policies themselves, as we show in Table 1. For this reason, we believe that the state fixed-effects models are a more accurate representation of the effect of NSO policies on natural gas consumption. Another explanation is that the control for only months covered by NSO policies (along with the Heating Degree Days variable) are not picking up enough of the seasonal variation in natural gas usage that is correlated with when policies begin and end in the calendar year.

4.3. Heterogeneous policy results

Tables 4 (two-way fixed effects) and 5 (difference-in-difference) show results for estimating Eqs. (3) and (4), which explore how policy heterogeneity impacts our results. Exploring how variation in NSO policies affects natural gas usage is also of interest because it may shed light on how to reduce inefficient consumption, but still offer some redistribution to the neediest consumers. One potential method for targeting the neediest consumers is to limit the customer group(s) they protect. For example, a policy that only covers customers who must demonstrate medical or financial need may lead to less inefficiency than a policy that prevents shut-offs for all customers.

Table 4. Natural gas consumption and NSO policy heterogeneity: two-way FE estimates.

	Covers All		**Need Based**		**Vulnerable**		**Payment Plan**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
*Policy Type*NSO Active*	0.070***	0.041**	0.092***	0.057***	−0.004	−0.004	−0.062***	−0.108***
	(0.023)	(0.020)	(0.011)	(0.009)	(0.012)	(0.010)	(0.016)	(0.013)
Heating Degree Days	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Retail Price	−0.050***	−0.034***	−0.052***	−0.035***	−0.049***	−0.034***	−0.050***	−0.034***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Median Income (thousands)	−0.001	0.001	−0.001	0.001	−0.001	0.001	−0.001	0.001
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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	Covers All		Need Based		Vulnerable		Payment Plan	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Month-Year Effects	Yes	No	Yes	No	Yes	No	Yes	No
Region × Month × Year Effects	No	Yes	No	Yes	No	Yes	No	Yes
N	2999	2999	2999	2999	2999	2999	2999	2999
R-Squared	0.977	0.988	0.977	0.988	0.977	0.988	0.977	0.988

The dependent variable in all regressions is the natural log of monthly natural gas consumption (millions of cubic feet) per capita. Covers All are NSO policies that cover the entire population in a state, with no pre-qualified characteristics. Need Based indicates a date based policy that is active for customers with demonstrated financial hardship, unemployment, recipients of government welfare, etc. Vulnerable indicates a date based policy that is active for customers with illness, disability, and/or elderly or very young customers. Payment Plan indicates a date based policy that is active for customers who commit to a payment plan to pay their outstanding bill. NSO Active represents the interaction between a state with an NSO policy and a month when the policy is active for date-based NSO policies only. Months that are partially covered by NSO policies are considered fully covered in the data. The unit of observation is a state-month. Standard errors clustered at State level are shown in parentheses.

***

$p < 0.01$.

**

$p < 0.05$.

Table 5. Natural gas consumption and NSO policy heterogeneity: D-i-D estimates.

	Covers All		Need Based		Vulnerable		Payment Plan	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
*Policy Type*NSO State*	−0.150***	−0.192***	−0.248***	−0.306***	−0.124***	−0.132***	0.124**	0.132**
	(0.054)	(0.054)	(0.033)	(0.033)	(0.032)	(0.032)	(0.042)	(0.042)
Month Covered	0.433***	0.429***	0.382***	0.368***	0.419***	0.416***	0.428***	0.425***
	(0.039)	(0.039)	(0.039)	(0.038)	(0.038)	(0.039)	(0.038)	(0.038)
*Policy Type*NSO Active*	0.249**	0.279**	0.186***	0.215***	0.218***	0.236***	0.047	0.045
	(0.086)	(0.085)	(0.039)	(0.039)	(0.046)	(0.045)	(0.058)	(0.057)
Heating Degree Days	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Retail Price	−0.095***	−0.108***	−0.095***	−0.108***	−0.0947***	−0.108***	−0.096***	−0.109***
	(0.020)	(0.022)	(0.020)	(0.024)	(0.021)	(0.023)	(0.020)	(0.022)
Median Income (thousands)	0.007	0.009	0.007	0.009	0.007	0.009	0.005	0.006
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.008)	(0.008)
Year Dummies	No	Yes	No	Yes	No	Yes	No	Yes
N	2999	2999	2999	2999	2999	2999	2999	2999
R-Squared	0.648	0.662	0.653	0.670	0.649	0.663	0.649	0.663

The dependent variable in all regressions is the natural log of monthly natural gas consumption (millions of cubic feet) per capita. Covers All are NSO policies that cover the entire population in a state, with no pre-qualified characteristics. Need Based indicates a date based policy that is active for customers with demonstrated financial hardship, unemployment, recipients of government welfare, etc. Vulnerable indicates a date based policy that is active for customers with illness, disability, and/or elderly or very young customers. Payment Plan indicates a date based policy that is active for customers who commit to a payment plan to pay their outstanding bill. NSO State represents a dummy variable indicating a state that has a date-based NSO policy. Month covered represents a dummy variable for months when NSO policies are active. NSO Active represents the interaction between a state with an NSO policy and a month when the policy is active for date-based NSO policies only. Months that are partially covered by NSO policies are considered fully covered in the data. The unit of observation is a state-month. Standard errors clustered at State level are shown in parentheses.

**

$p < 0.05$.

Table 4 lends some support to the idea that the heterogeneous NSO policies have differential effects on natural gas consumption. Columns (1) and (2) show estimates of the impacts of NSO polices that cover all customers, regardless of circumstance, on natural gas consumption. The magnitude of these results suggests that NSO policies covering all customers increase natural gas usage between 4.1 and 7%, statistically significant at conventional levels. This specification uses all other NSO policies as the comparison group, indicating state policies that cover all customers induce more natural gas usage than other types of NSO policies. Columns (3) and (4) of Table 4 show results for date-based NSO policies that also require the customer to demonstrate some type of financial need. These results show that NSO policies that are need-based (in addition to date-based) increase natural gas consumption by between 5.7 and 9.2%, statistically significant in both specifications.

Columns (5)–(8) of Table 4 show results for date based NSO policies that only cover the vulnerable populations or those that agree to a payment plan, respectively. The results for NSO policies that only cover vulnerable populations are essentially zero in magnitude, and not statistically significant. The results for NSO policies that only cover those that agree to a payment plan are large but *negative* – suggesting that this dimension of the policy could actually work to reduce consumption among covered populations relative to other types of NSO policies.

The difference-in-difference results for heterogeneous NSO policies are shown in Table 5. The results for policies that cover all customers and that are need based remain consistent with the two-way fixed effects specifications. The effect of a covers all policy is larger in the difference-in-difference specification, showing that NSO policies that cover all residents increase natural gas consumption between 24.9 and 27.9%.

4.4. Alternative estimation: propensity score matching

The primary assumption driving both the two-way fixed effects and difference-in-difference models is that there are no simultaneous changes in areas where NSO policies are active at the time they are active. Ultimately, this assumption is not testable as it is always possible that unobservable changes are happening. However, if unobservables are correlated with observable differences between control and treated areas, we can limit the influence of unobservable factors by conditioning the sample on observable characteristics. To that end we use a variant of the propensity-score model demonstrated in Crump et al. (2009), that suggests trimming the estimation sample by some value of a propensity score. This procedure first requires estimation of the likelihood that a state adopts a date-based NSO policy:

(5)

Where NSO is a (0,1) indicator at the state level for places that have a date based NSO policy. X represents the same control variables used in our primary estimation, but averaged to the state level for all months of our data. We also include regional dummy variables, σ_t. We use the estimated coefficients from (5) to generate a prediction that

each state implements an NSO policy and use this variable to create a sub-sample for estimation. Our sub-sample includes all states in the top half of the predicted NSO policy distribution, and we use that group to re-estimate our primary models.

Table 6 shows the results for both the two-way fixed effect and difference-in-difference models using the propensity score trimmed sample. The difference-in-difference estimation produces much larger magnitude results, on the order of 30–38% increase in natural gas consumption. The two-way fixed effects models produce diverging results. The standard two-way fixed effects model produces results that are roughly double the magnitude of our primary results, statistically significant at the one-percent level (suggesting in increase in natural gas consumption between 8.7 and 9.8%). The model that uses region specific month-year effects produces a null result that is small in magnitude and actually has a negative sign.

Table 6. Natural gas consumption and NSO policies: matching sample estimates.

	Two Way FE Model				**D-i-D Model**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
NSO Active	0.087***	0.098***	−0.012	−0.002	0.308***	0.355***	0.310***	0.382***
	(0.016)	(0.015)	(0.013)	(0.012)	(0.062)	(0.056)	(0.062)	(0.055)
Year Dummies	No	No	No	No	No	No	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Month-Year Effects	Yes	Yes	No	No	No	No	No	No
Region × Month × Year Effects	No	No	Yes	Yes	No	No	No	No
N	2064	2064	2064	2064	2064	2064	2064	2064
R-Squared	0.979	0.983	0.990	0.992	0.507	0.593	0.508	0.611

Dependent variable is natural log of monthly natural gas consumption (millions of cubic feet) per capita. Sample includes all states with a propensity score above the median value (0.7176) as generated from estimates in Eq. (5). Estimates in odd numbered columns include controls for Heating Degree Days. Estimates in even numbered columns include Heating Degree Days, Retail Price, and Median Income. Standard errors clustered at State level in parentheses.

***

$p < 0.01$.

5. Conclusion

This paper offers the first examination of the effect of NSO policies on natural gas markets and finds that they lead to significantly higher consumption levels. Our preferred specifications suggest that activation of a NSO policy increases natural gas consumption by between 4.7 and 4.8%, resulting in a total increase of between 66 and 67 billion cubic feet of natural gas consumed per winter season in covered states, at a value of as much as $950–970 million annually. The magnitude of the results we find suggests consumption increases as high as 24.6% among households that are likely to be covered by NSO policies.

Two explanations seem appropriate for our findings. The first, and most basic, is that NSO policies work to provide a service to the less fortunate that they would otherwise not be able to afford- home heating during the winter months. This view would associate the consumption increase we find with a transfer of resources, and could easily be justified on equity grounds, or on efficiency grounds if there is a negative externality caused by poor health outcomes. An additional, and possibly alternative explanation, is that NSO policies induce moral hazard because they do not require payment for services used– effectively making the price zero for a time.[12] In this way, NSO policies may be leading some customers to consume more gas than is necessary for basic comfort.[13] In this view, the increase in consumption resulting from NSO policies would be inefficient.

As our empirical work features only date-based policies as the treatment, and control states have temperature or other need-based NSO policies, we may be picking up more of the moral hazard induced consumption than equity associated consumption. Also, the heterogeneous policy effects we find are strongest for policies that cover all residents, further supporting the moral hazard explanation, although ultimately we cannot definitively distinguish between the two in our empirical work. Our work highlights a classic trade-off between efficiency and equity in policy design. On the one hand, if the goal of the policy is to alleviate human suffering, some NSO policy that increases consumption may be justified; however, to the extent that these policies lead to moral hazard, it may be worthwhile to re-examine the details of NSO policies.

Acknowledgements

We would like to thank Andy Meyer for helpful comments on an earlier draft, as well as participants at the Arts and Sciences Colloquium of the University of the Pacific, and conference participants at the Southern Regional Science Meetings

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1

See Puller and West (2013) for a recent discussion of efficient pricing in natural gas (and electricity) markets.

2

Hausman (1979) first identified that discount rates would need to be on the order of 25% annually to explain the difference between willingness to pay between increasing energy conservation (lower operating costs) and higher initial capital costs. Jaffe and Stavins (1994) first referred to the seemingly too gradual adoption of energy saving technology as a paradox. See Allcott and Wozny (2014) for a recent empirical demonstration of the energy paradox in the market for automobiles as it relates to fuel efficiency and gasoline prices.

3

These are exclusively cold-weather related. Warm-weather no-shut-off policies are designed to prevent electricity shut-offs; in general, natural gas consumption decreases during the hottest summer days because the heat leads households to avoid turning on the oven and other gas-powered appliances.

4

Two states, Kentucky and New Hampshire, have policies that require utility companies to reconnect service for certain customer groups during the winter months. These are

considered the same as no-shut-off policies for purposes of this paper.

5

The National Regulatory Research Institute survey reports data from natural gas customer accounts in California, Colorado, Connecticut, Delaware, Illinois, Indiana, Maine, Missouri, Nevada, Ohio, Pennsylvania, and Tennessee. We use their reported number of accounts, accounts in arrears (at least 30 days over-due), and disconnects at the state-level to create weighted national averages.

6

Policies start and end on either the 1st, the 15th, or the end of the month. For example, Minnesota's policy covers from October 15th to April 15th, while Missouri's policy begins on November 1st and ends on March 31st. For purposes of this paper, which uses month-level data, if a policy is effective for any day in a given month, it is considered effective for the entire month.

7

We choose October to April as the covered months because these months cover all time periods where any state has an active policy, and are generally months where most natural gas is used. The actual times when policies start and stop is reflected in the *NSO Active* variable. Results are robust to widening or narrowing the window of months contained in *Month Covered*.

8

Howat and Devanthary (2006); Harak and Wein (2008); Harak et al. (2011); LIHEAP Clearinghouse (2013).

9

We generally reject the null hypothesis that the price variable estimates are consistent in our models. Importantly, including or excluding the price variable has little to no effect on estimates of the NSO policy variable. We caution the reader in interpreting the coefficient estimates on price in our models.

10

We've also experimented with controlling for other factors that have the potential to change seasonally at the state level. Including these factors, for example poverty rates or unemployment rates, does not change any of our results.

11

Wholesale prices are about half the retail price during the years of our data, so calculating the increase in cost from a wholesale price perspective would cut these figures in half.

12

Davis and Muehlegger (2010) actually find evidence that in many cases customers face a price for natural gas that is higher than the marginal cost of production, which could lead to inefficiently low consumption of natural gas.

13

See Wirl and Orasch (1998) for an excellent discussion and theoretical treatment of moral hazard issues in energy consumption.