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Characterization of utility programs' enrollment by income and region

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Abstract

Utility programs aimed at promoting energy efficiency, demand side management, or reducing burdens on low income households have been used as key policy mechanisms to promote energy and emissions reductions and to improve the level of energy services provided. However, to date, there are few characterizations of how the adoption of and enrollment in different types of programs varies geographically, by demographic characteristics and by consumption patterns, within a utility territory. Understanding uptake can help identify equity gaps and areas for increased outreach. In this work, we use a stratified sample of approximately 30,000 households in Pacific Gas & Electric (PG&E) service territory from 2008 to 2011, complemented with demand-side management and energy efficiency program participation, and with census block level demographic information, to better understand where programs are adopted, and by whom. We find that participation in California Alternate Rates for Energy (CARE) – a program that provides lower electricity rates for eligible households that have low income – is prevalent across all climate regions, and grows substantially over time in all regions and income segments. Energy efficiency rebate programs are predominantly used by households located in census blocks that are in the high median income group, even with free efficiency measures for low-income households. The SmartAC demand response program, which requires smart meter installation, surpassed 5% participation in high- and middle-income households in the warmer Central Valley by the end of 2010, within two years of meter installation. Overall, these results suggest that there are important demographic differences in program participation across climate regions and program types. Understanding these differences can inform deployment of similar programs by other utilities, and identify areas for additional outreach to spur appropriate adoption.

Introduction

The need to reduce the effects of climate change and to reduce energy consumption from fuel sources that have adverse health effects has led numerous US states to promote energy efficiency policies, with the intended goal of reducing energy consumption. Today in the United States, 20 states have energy efficiency resources standards and 8 states have energy efficiency voluntary goals (1).

Overall, utilities in the United States, spend about $4.8 billion per year in energy efficiency programs (about $3.9 billion in electricity programs, and $0.8 billion on natural gas efficiency programs) (2). Scenarios from the Lawrence Berkeley National Laboratory (LBNL) suggest that doubling the level of spending in energy efficiency programs between 2010 and 2025 would lead to increments annual savings increasing from of 18 TWh in 2010 to 29 TWh in 2025 (2). However, there is large uncertainty regarding the future levels of spending in energy efficiency programs and their respective effective energy efficiency savings in the future.

California has been a leader in energy efficiency policies and activities: it is the state that spends the most on energy efficiency programs, about $1.1 billion total in year 2010 (2). Utilities

in California use a series of policy mechanisms to achieve energy efficiency and peak load reductions.

In this work we use a regionally stratified sample of smart meter data of approximately 30,000 households in Pacific Gas & Electric's (PG&E) service territory from 2008 to 2011, which was provided by the Wharton Customer Analytics Initiative (WCAI) and the Wharton School in an agreement with PG&E. PG&E is a major electric and gas utility with 5.4 million electricity customer accounts (3).

The rest of our paper is organized as follows. First, we present the data and methods used. This is followed by the results and analysis, and finally we conclude.

Data and Methods

PG&E SMART METER PROGRAM

In this work, we use a regionally stratified sample of smart meter data of approximately 30,000 households in Pacific Gas & Electric's (PG&E) service territory from 2008 to 2011. The data include 8,597 households from the Coast, 11,391 from the Inland Hills, and 10,217 from the Central Valley, three major climate regions in PG&E territory, displayed graphically in Figure 1. This study period of 2008–2011 coincided with the roll-out of the smart meter program, so the number of households and smart meter readings in the dataset increases over time, as shown in Figure 2.

The smart meter readings are communicated back to a base station, from which they are relayed back to PG&E. We use daily smart meter readings, which we also aggregate to monthly data.

Our dataset includes two major household-related identifiers: a service point id (which identifies the location of the smart meter) and an account id (that identifies the customer, i.e., if a customer moves to a new house, the account id is maintained, but the customer will have a new service point id). Results below are in terms of electric service point id, which generally corresponds to a single household in a single location.

Households with smart meters were randomly sampled by PG&E at the end of the 2011. Data were gathered for each of these households for the duration of the period in which the household had an active smart meter. Figure 2 shows meter installation in our sample by region over time. As of August 2011, smart meters were installed for 4.7 millions of PG&E's 5.25 million residential customers (4). As a result, the dataset should be an unbiased sample of households in each region at the end of 2011. Earlier data are unbiased only to the extent that PG&E's smart meter deployment program can be considered random. This assumption is not contradicted by any of our findings, but without access to PG&E's internal documents it is the possibility of non-random selection cannot be ruled out.

The very small sample sizes in early deployment in each region leads to high variance in estimated program participation rates. We exclude the year 2008 from most of our analysis because of the extremely low sample size in the Inland Hills and Coast (see Figure 2). The Coast sees relatively small sample sizes, below 1,000 households, late as mid-2010.

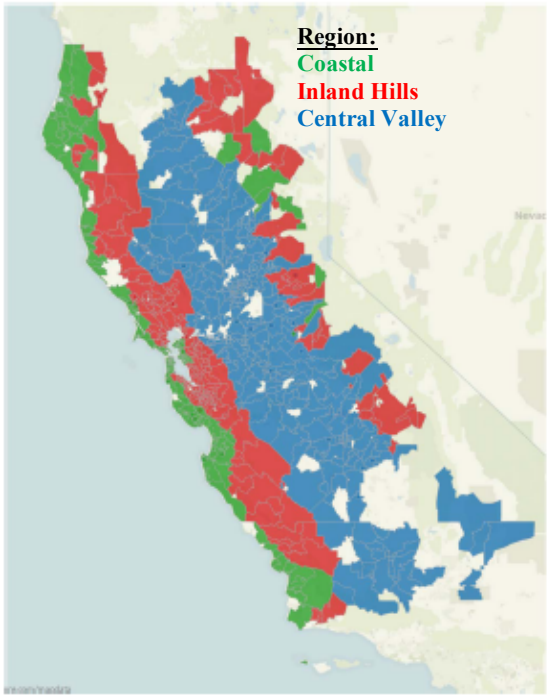

Figure 1. Regions in the PG&E service territory. PG&E randomly selected approximately 10,000 households from each of the region to construct the sample. Figure from the Wharton Customer Analytics Initiative.

PG&E ENERGY EFFICIENCY AND DSM PROGRAMS

During the period for which the smart meter data were collected, PG&E had several programs that households could participate in, such as energy efficiency, demand side management (DSM) and low-income programs, in addition to the rebate program. Key programs active during the period of observation include:

- The **California Alternate Rates for Energy** (CARE) program is an energy subsidy, providing an average discount of 33 % for low-income households in PG&E territory.
- The **Balanced Payment Plan** (BPP) program provides a bill smoothing service, in which the monthly bill is based average consumption in the previous year.
- The **Smart AC program** demand response program provides a one-time $50 incentive payment, in exchange for installation of a device on the cooling unit that allows PG&E to cycle the unit off for up to 15 of every 30 minutes during peak load events.
- **Rebate programs**, which subsidize appliances, end-use energy devices, and retrofits. Customers receive efficiency rebates only after purchasing qualifying equipment or services and submitting an application to PG&E. Households are eligible to participate in the rebate programs multiple times.

We exclude the following programs from detailed analysis due to low participation rates and/or unavailability to new customers:

- The **Climate Smart program** allows households to purchase carbon offsets through PG&E via their monthly utility bill.

- The **Direct Access program** allows customers to purchase their electricity from alternative (non-PG&E) power providers. New customers have not been able to join the Direct Access program since the California energy crisis in 2001, though existing customers have been able to remain in the program.
- The **Smart Rate program** provides customers with a 3-cent per kWh discount in exchange for accepting a 60 cent per kWh rate during summer peaking hours.

In the results section, we characterize the number of participants in each of these programs over time and by the level of income associated with their census block.

PG&E CUSTOMERS

The original dataset provided by PG&E includes smart meter electricity reading information and program enrollment. However, it does not include information on demographics or housing values at the customer id level. To overcome that limitation, we have complemented our dataset with 2010 Census data at the census block level. In Table 1, we provide the summary statistics of the census block data associated with the households in our sample. To be clear, if a household is associated with a location in census block *a*, we then associate that household observation with the median home value in census block *a*. The information displayed in Table 1 thus shows the median values for several demographic quantities across our sample of census block median characteristics for each household by climate region (Central Valley, Inland Hills, Coast and overall).

We observe that there are key differences across climate regions, with median home values in the census block groups in Inland Hills and the Coast regions being almost twice as large as those in Central Valley. Similarly, the levels of median income in Census blocks in Central Valley are lower than in the Inland Hills or the Coast. The number of renters is higher in the Coastal region, where the median home values are the highest. There is a striking difference between the number of census block regions percent of poor, with the figure in the Central Valley being twice as high as in Inland Hills.

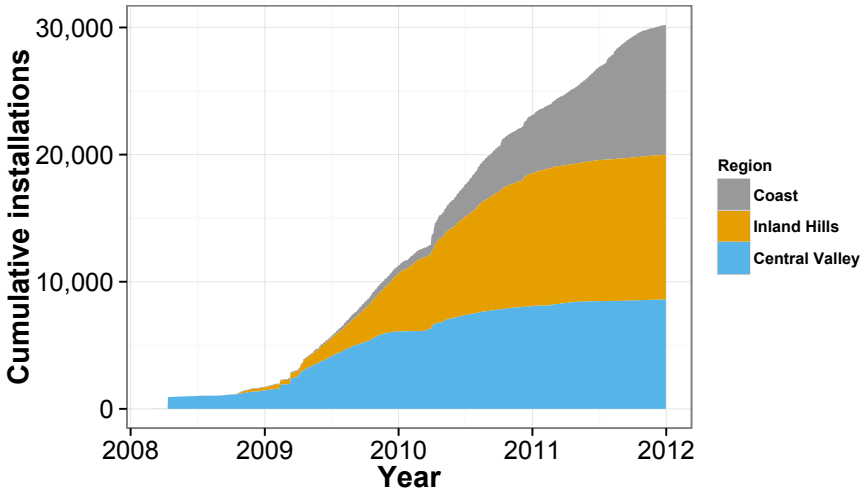

Figure 2. Smart meter rollout for our sample, March 1, 2008, to December 31, 2011, by region. Note: Figure reproduced from Meyer, Sherwin and Azevedo, working paper.

Table 1. Summary statistics for 2010 census block neighborhoods of households in the sample*.

	Central Valley	Inland Hills	Coast	Overall
Median of Median Home Value*	282,000	586,000	597,000	479,000
Median of Median Income*	51,800	78,500	63,400	65,600
Median % Renters	34	32	51	38
Median % Poor	12	6	9	8
Median % w/ Bachelors (or higher)	17	38	40	32
Number of households	8,597	11,391	10,217	30,426

** These values are medians from our sample of Census block neighborhood medians. The values are top-coded by the US Census at $1M and $250k, respectively. We report the values rounded the median home value to $1,000 and the median income values to $100 in the table for simplicity. Note: Table reproduced from Meyer, Sherwin and Azevedo, working paper.*

METHODS

We first characterize the roll out of the smart meter program by climate region. To do so, we use the household service point id and the census division block identification provided in the PG&E dataset.

We then characterize the distribution of daily electricity consumption during the period for which the data were collected for each of the climate zones using daily smart meter readings. We provide the information on the daily electricity consumption in each region over time by decile.

Finally, we assess the enrollment rate of our samples in different PG&E programs as a fraction of households in the dataset over time, for the entire samples, as well as by climate region and census block income. To do so, we identify income segments based on median census block income, with thresholds of $52,252 and $81,572, the ⅓ and ⅔ fractiles of households in our sample respectively.

Results

THE ROLL OUT OF THE SMART METER PROGRAM BY CLIMATE REGION

In Figure 2, we show the deployment of the smart meter program observed in our sample. In our sample, smart meter deployment began in the Central Valley, followed by Inland Hills, and finally by the Coast region. Toward the end of our sample period (end of 2011) our sample contains about the same number of households in each climate region.

ELECTRICITY CONSUMPTION IN OUR SAMPLE BY INCOME AND REGION

In Figure 3 we illustrate the daily electricity consumption over time and by climate region in our sample. We observe that the Coast has lower overall electricity consumption than the Inland Hills or the Central Valley, likely due in part to milder weather. We also note that the distribution of daily electricity consumption is tighter for the Coast and Inland Hills when compared to the daily distributions of electricity consumption for households in Central Valley. The summer spikes (largely attributable air conditioner use) are also notable in the Central Valley region.

WHO ENROLLS IN ENERGY EFFICIENCY, DSM AND LOW INCOME PROGRAMS?

In Figure 4, we show the share of enrollments for all programs over time in our sample. We observe that the California Alternate Rates for Energy (CARE) program is the most prevalent program, with enrollments reaching 30 % of the entire sample of households. This share is remarkable, as households must have income below 200 % of the federal poverty line, or qualify for another means-tested low-income program such as Medicaid (5). Of course, the goal of the CARE program is not to reduce electricity consumption or promote energy efficiency, but instead to ensure that low income households are able to have affordable access to energy services.

The Balanced Payment Plan (BPP), which provides a bill smoothing service, in which PG&E calculates the household's average monthly utility bill and the customer pays a flat amount for each monthly billing cycle, comes second in terms of program participation, but captures less than 8 % of all households in our sample at any point in time.

To understand the differences in program participation by climate region and by income level, in Figure 5 we parse out the program enrollment data from our dataset by these factors. For CARE, BPP, and Smart AC the values represent the share of households in the dataset that were participating the program at that point in time. For the rebate program the share indicates the portion of households in the sample that applied for at least one rebate prior to that date. We exclude Direct Access, Climate

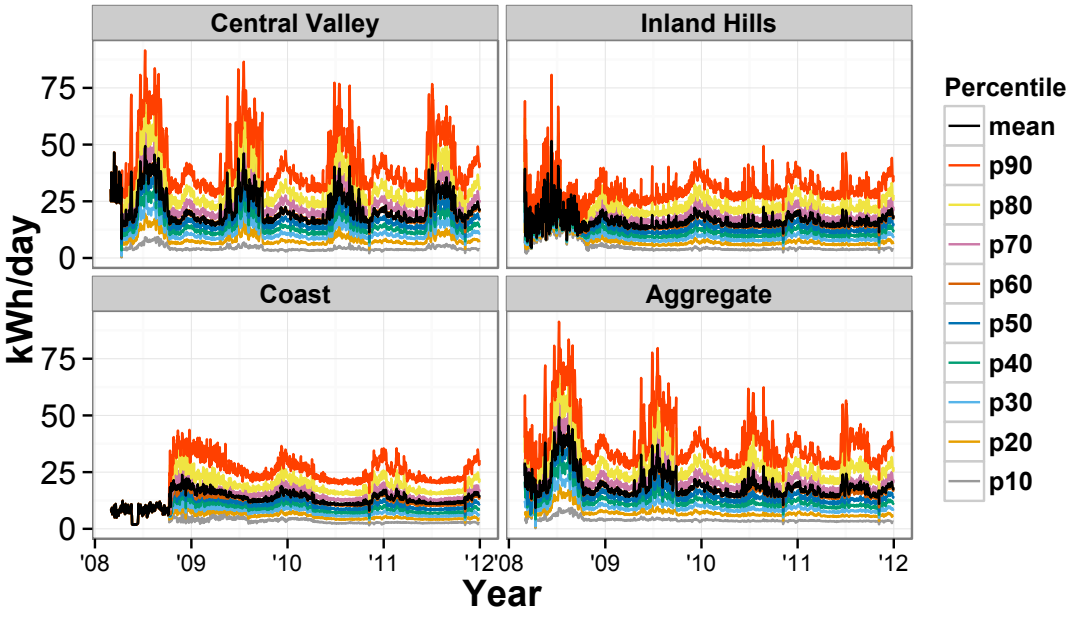

Figure 3. Deciles of daily household electricity consumption shaded by region and day, from the 10th percentile to the 90th percentile. Note: Figure reproduced from Meyer, Sherwin and Azevedo, working paper.

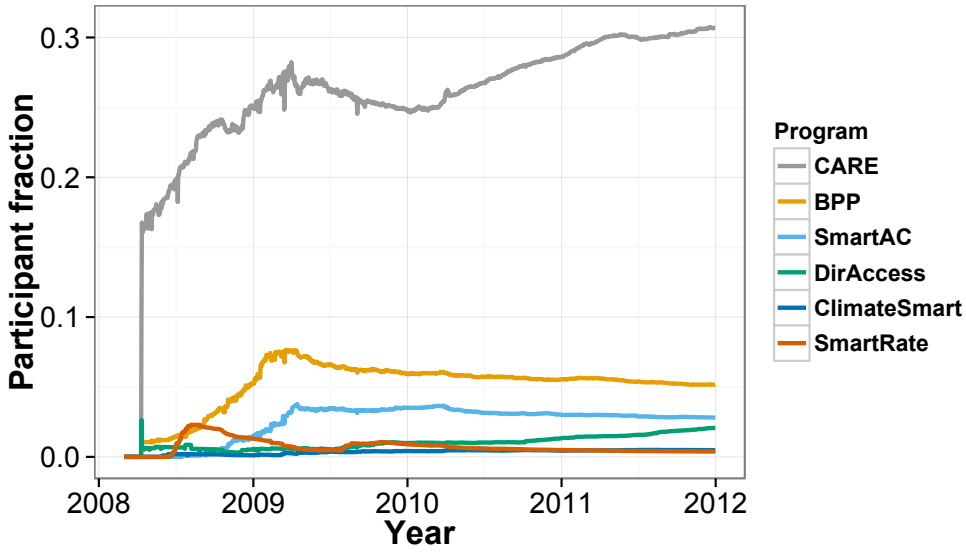

Figure 4. Enrollment rate in PG&E programs as a fraction of households in the dataset over time. The CARE low-income subsidy is by far the most prevalent. We exclude DirAccess, ClimateSmart, and SmartRate from detailed analysis due to low participation rates, and the fact that PG&E no longer allows new enrollment in DirAccess. Note: Figure reproduced from Meyer, Sherwin and Azevedo, working paper.

Smart, and Smart Rate from detailed analysis due to low participation rates, and the fact that PG&E no longer allows new enrollment in Direct Access. Note that Figure 5 begins in 2009, due to small sample considerations in 2008 in all three regions (see Figure 2).

We find that participation in the CARE program is prevalent across all climate regions, but, unsurprisingly, overwhelmingly high in low median income census blocks. CARE enrollment also increases substantially over the study period in all groups except high-income Coastal households. In households in low-income census blocks in the Central Valley, CARE program enrollment grows from just over 20 % in 2008 to over 50 % in 2011 (see Figure 5A). Similarly, in census division blocks with low median income in the Coast and Inland Hills CARE program participation exceeds 40 % in analogous households. This most of substantial increase in CARE enrollment is likely attributable to the 2008 financial crisis and subprime mortgage collapse, and the subsequent Great Recession.

Notably, in census blocks with mid median income range, participation in CARE is still very high (about 40 % in 2011 in Central Valley, and about 20 % in the Coast and Inland Hills regions). Even high-income census blocks see CARE enrollment rates between 10 % and 20 % in 2011. This is likely a measure of both local income inequality, and a product of language in CARE eligibility criteria that allows households participating in various social assistance programs to enroll in CARE regardless of income (6). This may in part also be a product of the program's randomized ex-post income verification process, which only selects a fraction, approximately 8 % of participants annually, to verify eligibility for the program (7).

Energy efficiency rebates for households in low-income census blocks have roughly a 5 % participation rate in all three regions at the end of 2011. This is likely predominantly due to the Energy Savings Assistance (ESA) program, which offers free energy efficiency upgrades for households meeting need-based eligibility criteria similar to the CARE program (8).

Participation in non-CARE programs is modest by comparison. It is notable that energy efficiency rebate programs seem to be predominantly used by households located in high-income census blocks, with participation between 10 % and 15 % in all three regions at the end of 2011.

Participation in the long-term bill smoothing Balanced Payment Plan (BPP) is highest in the Central Valley (Figure 5B), where summer air conditioning loads drive high intra-year variability in electricity consumption (Figure 3). Participation is relatively stable from 2009 onward in all regions and population segments, with the highest level at 10 % participation for high-income census blocks in the Central Valley, and lowest level around 3 % for low-income census blocks in the Coast. Participation for low-income census blocks in the Central Valley is roughly 6 %, substantially lower than for higher-income households. Given the 90 %+ penetration of air conditioning in the Central Valley (9) and the heightened vulnerability of low-income households to unexpectedly high bills, this is an indication that BPP may be under-subscribed in low-income households in the Central Valley.

The SmartAC program, which compensates customers in exchange for limited utility control of residential air conditioners on hot days, requires smart meter installation. There is rapid uptake of the program to over 5 % participation for middle- and high-income census blocks in Central Valley by 2009, one year after smart meter installations began en masse (Figure 5b). This indicates that such programs can be rapidly deployed in areas with high summer air conditioning loads. SmartAC uptake in the Inland Hills is non-negligible, but stays at roughly half the rate of the Central Valley in all three income segments. There is essentially no uptake on the Coast, which has a milder climate and negligible summer residential cooling demand (Figure 3).

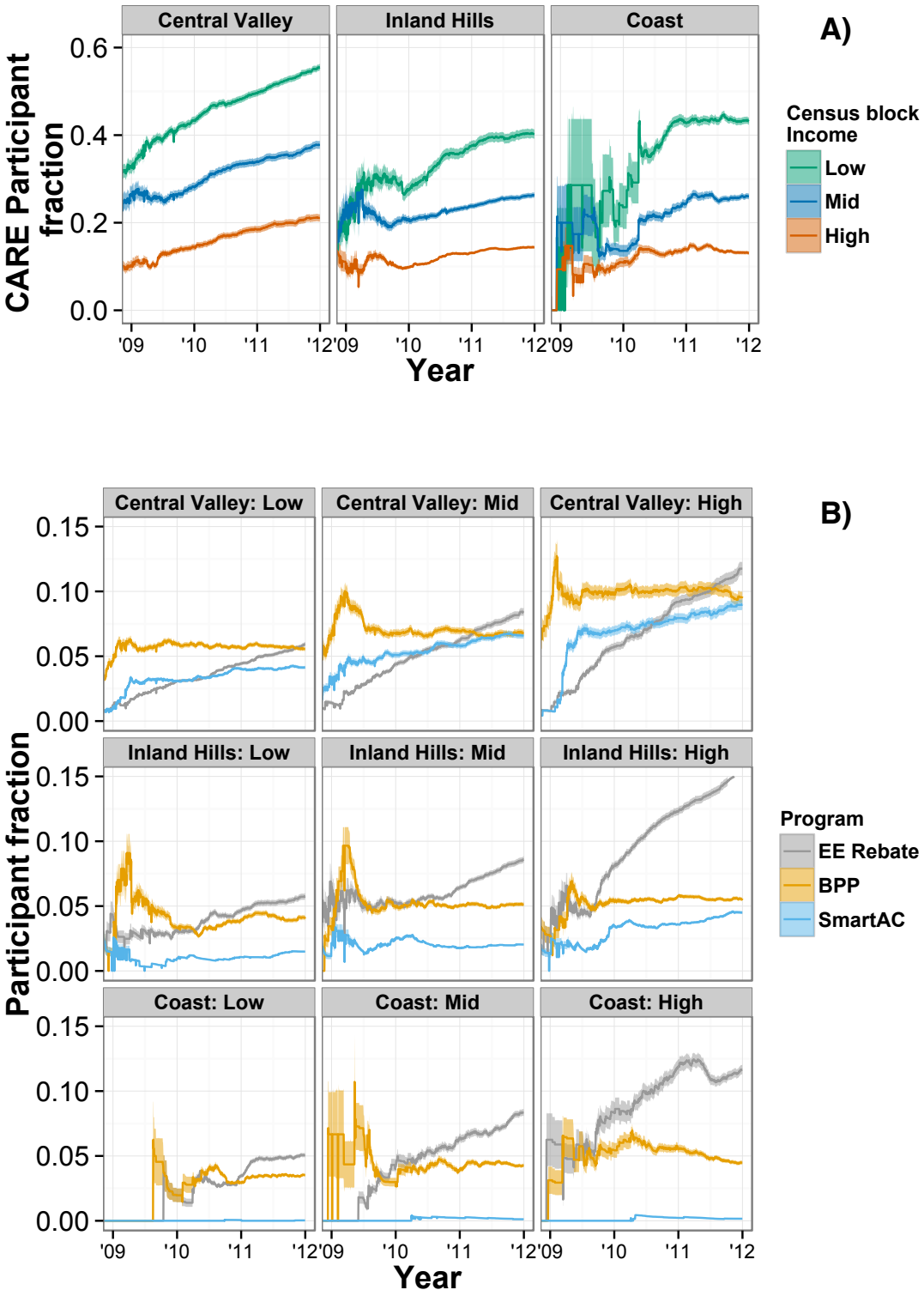

Figure 5. Enrollment rate in PG&E programs as a fraction of households in the dataset over time, by region and median census block median income, with thresholds of $52,252.33 and $81,572.00, the ⅓ and ⅔ fractiles of households in our sample respectively. Shaded areas are 95 % probability interval, considering sample error. A) A large fraction of CARE participants lives outside low-income census blocks. The increasing trend in CARE participation is likely a product of smart meter deployment decisions, not changes in population enrollment. B) Within each region, households in wealthier census blocks have higher participation in energy efficiency rebates, the Balanced Payment Plan bill averaging program, and the SmartAC demand response program. The SmartAC program, which requires a smart meter, grew rapidly in the warmer Central Valley and Inland Hills.

Conclusions and Future Work

Utilities in the United States are pursuing a variety of programs to reduce electricity consumption and to provide affordable energy services. California has been a leader in deploying these programs – both for energy efficiency, and low income bill assistance.

The emergence of smart meter data and temporally detailed data on program enrollment and efficiency incentive use will allow utilities and policy makers to better understand program uptake across a wide range of geographic and demographic categories. Such analyses can help ensure programs are reaching intended populations and identify and address equity concerns. In addition, utilities considering similar programs in climates similar to the utility analyzed can gain insight into likely uptake patterns across income levels. In this work, we provide a first characterization of program enrollment by region for a sizeable random sample within the PG&E territory. Our results suggest that there are important demographic differences in program participation across climate regions and program types.

Our main conclusions are as follows:

- Enrollment in all non-means-tested programs increases with census block income in all three regions.
- This is the case even with the bill-smoothing Balanced Payment Plan. This program may be under-subscribed among low-income households, which may stand to disproportionately benefit from bill smoothing, particularly in areas like the Central Valley with high summer air conditioning load.
- Even with free energy efficiency upgrades from the low-income Energy Savings Assistance Program, participation in energy efficiency rebates is highest in wealthier census blocks.
- The rapid uptake of the SmartAC program after smart meter installation suggests that such a program can be rapidly deployed as smart meters are installed in other regions with high summer air conditioning loads.
- Although participation in the CARE low-income bill subsidy is most highly concentrated in low-income census blocks, there is nontrivial participation even in high-income census blocks in all three regions. Further investigation is required to determine the extent to which high-income households themselves benefit from the subsidy.

In future work, we will assess how electricity consumption patterns differ across participants in these different programs.

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