

The Effects of Policy Announcement, Prices, and Subsidies on Water Consumption

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Abstract

With increasing water security challenges, water utilities around the world face complex decisions on water supply and demand management. This study investigates the effects of price and subsidy increases on water conservation in Singapore. Using anonymized monthly billing data on water consumption for 2.2 million residential accounts over 10 years, our difference-in-differences estimates show that the announcement of a two-phased 30% price increase reduces water consumption by 3.7% more for the public housing, relative to the private apartments. The announcement effect is larger than the implementation of price increase. Consumers with lower water usage respond more to the announcement of price hike while consumers with higher usage respond more to its implementation. An increase in utility subsidy reduces low-income households' financial burden but does not affect water consumption possibly due to consumers' low attentiveness to the subsidy change. The results suggest that the traditional market-based policy instruments, such as price and subsidy, could be combined with attention priming to achieve sustainable outcomes with minimal requirement on technology advancement and institutional innovation.

Cities worldwide are facing increasing water security challenges due to misalignment between rising water demand and declining resource availability. Supply-side solutions often involve costly infrastructure development and technology advancement. As such, a wide range of policy instruments have been implemented to reduce water demand, including rationing, mandated technology, efficiency rebate, education, social norms, etc. Water pricing, however, has not been integrated into the portfolio of measures by many utilities and regulators, despite its cost-effectiveness¹⁻⁴ and ease of implementation⁵, due to low price elasticity of water and the welfare implications of pricing policies⁶.

The effectiveness of price as a lever of water demand depends on its elasticity. Traditionally, residential water consumers exhibit low price elasticity of demand⁷⁻⁹. This has been attributed to the lack of information and understanding on price and quantity consumed^{10,11}. On the price side, study has shown that not including price information in the bill could reduce price elasticity by 30% or more¹⁰. The non-linear structure of increasing block rate, the most common water tariff structure, could make it difficult to accurately understand price information^{9,12,13}. Furthermore, inattention to price and its components¹⁴, and automatic payments^{15,16} may also obscure price signals. On the quantity consumed, passive tracking of water use, as a result of infrequent billing^{17,18} and systematically biased beliefs (i.e., underestimation of water use)¹⁹⁻²², prevents consumers from adjusting consumption according to price changes. Given the above, research has shown that improved understanding of price¹³ and water usage^{11,17,18,21} could both increase price elasticity of demand for residential water, therefore improving the effectiveness of pricing policies.

However, effective pricing policy in water conservation raises concerns on its potential regressive distributional effect. As low-income households spend a greater proportion of their income on water, they may be disproportionately affected by price increase.^{5,23} To address the potentially

regressive distributional effects, utility subsidies of various forms are often implemented alongside price increase.²⁴⁻²⁶ The subsidy, though intended to cope with rising utility costs, also reduces the effectiveness of price and may unintentionally increase water consumption.

Despite many studies focusing on the role of water pricing, utility subsidy, and information on water consumption individually, comprehensive empirical evidence on how these components interact with each other is rare. In this study, we evaluate the effect of the announcement and implementation of raising water price and utility subsidy on residential water consumption in Singapore.

Using anonymous monthly billing data on water consumption for more than 2.2 million accounts from all non-landed premises that houses 95% of the population, our difference-in-differences estimates show that the monthly water consumption for an average public housing household decreased by 3.7% more than the private apartment residents after the policy announcement and dropped by another 2.1% and 2.8% after the two-stage implementation of a 30% price increase respectively. The announcement accounts for 64% of the overall effects, likely due to improved public attention on water prices, especially among the households who use less water. Households with relatively high-water demand, who experienced a large increase in water bill, reduced more water consumption after the implementation of price increase. In contrast, the announcement and implementation of utility subsidy that help offset the adverse effect of water price increase, especially on low-income households, did not seem to have any impact on water consumption based on our evaluation on the 2012 and 2019 utility subsidy increase. This is potentially a result of inattention on the utility subsidy program due to its features of automatic eligibility, disbursement, and usage^{27,28}.

Our results provide important policy lessons for water utilities around the world, especially in metropolitan areas, that are considering water pricing as demand management and cost recovery tools. With climate change and increasing frequency of extreme weather events such as flooding and drought, water utilities are facing tremendous pressure in upgrading water supply facilities to cope with the uncertainty. Instead of the more common approach of small and frequent increases in water price, more and more water utilities may resort to sharper increases in water price, whose effect on water consumption and social welfare is not well established. In addition to providing empirical evidence on such effects, this study also points avenues for policy makers to address the potential regressive effects of the pricing policies with appropriate information and subsidy provision.

Our results shed light on the role of information in determining price perception and price elasticity of demand. We show that information provision via policy announcement could prime awareness of water price and effectively reduce residential water consumption. Such an announcement effect on consumer spending, consistent with the permanent income hypothesis that consumption decisions are based upon expected long-term average income, has been documented in household finance,²⁹ but not in the context of residential water consumption. Our empirical evidence shows that as water constitutes a very small proportion of household income, the mechanism of announcement effect is not limited to the anticipation of price increase.

Last but not least, this study contributes to a broader literature that shows how information could improve the effectiveness of market-based environmental policies in correcting externality³⁰ and how informative interventions could influence conservation behavior.³¹⁻³³

Effect of price increase announcement and implementation

Policy background: In Singapore, water is priced to reflect its scarcity and to reinforce the message that water is precious. The government does this through a long-run marginal cost pricing approach by pegging the water price to the cost of supplying the next drop of water, which will likely be from NEWater (highly treated reclaimed used water) and desalination. The water price, including water tariff, water conservation tax, and waterborne fee, takes the form of an increasing block tariff. Before the price increase, it cost 2.1 Singapore Dollar (S\$) per cubic meter (m^3) if the monthly household water consumption was below 40 m^3 and S\$2.61 for each unit consumed above this cutoff. Only less than 3% of the non-landed households from 2011 to 2019 were affected by the second block price. In February 2017, the Government of Singapore announced a 30% water price increase to be implemented in two stages in July 2017 and July 2018 (see Supplementary Table 1 for details) to reflect the increasing cost of water supply.

The announcement and implementation of the water price increase is likely to affect water consumption and this effect may differ across population sub-groups. The causal evaluation on these effects, however, is challenged by the lack of a clean control group as the water price increase is implemented nationwide. We leverage on the potential differences in the elasticity of demand for water among the residents of public versus private housing to identify the effect of price change using a difference-in-differences approach.

In Singapore, over 80% of the population lives in public housing developed and managed by the Housing and Development Board (HDB) and about 15% lives in private apartments. The average monthly income in 2017/2018 for residents of HDB flats, ranging from S\$2,521 for 1-1/2-room flats to S\$11,244 for 5-room and Executive flats, is much lower than residents of private apartments at S\$21,830 (Supplementary Table 2 Column (1)). Despite the income disparity, the monthly water bill for residents of HDB flats (S\$25 to S\$44 for various flat types before the price

increase) and private apartments (S\$33) are similar (Supplementary Table 2 Column (2)). The same water price change means differently across income groups, which may exert heterogeneous impacts on residents in public and private housing.

Figure 1 shows the unconditional mean of monthly water consumption, from January 2015 to December 2018, for HDB flats (panel (a)) and private apartments (panel (b)). We observe a discontinuity in water consumption around the announcement of the water price increase for HDB flats but not for private apartments. Using a regression discontinuity in time (RDIT) approach, we formally compare the monthly water consumption before and after the announcement of water price increase (equation (1) in Methods) for HDB flats and private apartments respectively. We find the discontinuity in water consumption to be statistically significant for HDB flats only (-4.7%, $P < 0.001$, 95% CI [-0.06, -0.04]). We further divide the time periods after the announcement of price changes into three time-windows: announcement period (March to July 2017), first price increase (August 2017 to July 2018) and second price increase (August 2018 to December 2018). We compare the mean water consumption during each window to that of the pre-announcement period (January 2015 to February 2017) by estimating equation (2). Again, we find statistically significant differences for HDB flats only (-3.1%, $P < 0.001$, 95% CI [-0.05, -0.01]; -5.2%, $P < 0.001$, 95% CI [-0.06, -0.04]; and -5.1%, $P < 0.001$, 95% CI [-0.06, -0.04]) in Supplementary Table 3. The estimates are consistent across various HDB flat types and are robust to alternative specifications, sample restrictions, and bandwidth (Supplementary Table 4).

The RDIT design alone, however, cannot eliminate the effect of other concurrent external shocks on residential water consumption. We therefore turn to a difference-in-differences approach comparing the water consumption before and after the price increase for HDB flats (treatment group), relative to private apartments (control group), to account for other coincidental changes

that are common to both. Although there is no credible evidence that water consumption by private apartments responds to price increase, the estimated effects should still be interpreted as the lower bound, not the full effect, of the announcement and implementation effects in residential sector.

Average treatment effect: Table 1 column (1) shows the average effect of price change on water consumption in HDB flats, relative to private apartments, by estimating equation (3) using observations from January 2015 to December 2018. Overall, the average water consumption for HDB flats has dropped by 5.8% ($P < 0.001$, 95% CI [-0.07, -0.05]) after the announcement of the price increase. This effect is both statistically and economically significant. Evaluated at the mean (17.32 m^3 for the treatment group before price change), this 5.8% reduction translates to almost 10 litres of water saved per capita per day, considering an average household size of 3.16 persons. This is equivalent to 56% of Singapore's goal to reduce residential water consumption from 148 litres per capita/day in 2016 to 130 litres by 2030.

Table 1 column (2) decomposes the overall effects into the announcement effect and additional implementation effects of the first and second price increases by estimating equation (4). The estimated announcement effect is 3.7% ($P < 0.001$, 95% CI [-0.05, -0.02]), accounting for 64% of the overall effect. In comparison, the effect of the first and second price increases are 2.1% ($P = 0.001$, 95% CI [-0.04, -0.01]) and 2.8% ($P < 0.001$, 95% CI [-0.04, -0.01]), respectively. As the two price increases for the first consumption block (less than 40 m^3 per month per household) are similar in percentage terms (13.8% and 14.6%) and 97% of the households are only affected by the first block price, the difference in the effect sizes of the two price increases are not statistically significant ($P = 0.565$). The estimated effects remain similar across model specifications, sample restrictions, treatment of outliers, and stand error clustering (Supplementary Table 6) and are consistent across regions/districts (Supplementary Figure 1). Event study that compares water

consumption between the treatment and control groups in each 6-month period (equation (5) in Methods) shows no credible evidence of rebound over time (Supplementary Figure 2(a)).

The validity of our difference-in-differences estimates rely on the parallel trend assumption. We estimate the difference in water consumption between the treatment and control groups for the six-month period before the announcement of water price increase in our estimation and find no evidence of any statistically significant differences (Table 1 columns (1) and (2)). Similarly, the event study estimates in Supplementary Figure 2(a) show that the difference in water consumption between the treatment and control groups in each 6-month period before the announcement of water price increase is not statistically different from zero (P -value=0.907 for joint hypothesis testing). We conduct additional tests³⁴ of the potential impact of differential linear pre-trends in the treatment and control groups and find the magnitudes of the conditional and unconditional biases to be substantially smaller than the treatment effects (Supplementary Figure 3). We further conduct placebo test by randomly assigning treatment timings during the pre-treatment time and find no statistically significant treatment effects (Supplementary Table 6). These results support the parallel trend assumption and justify our difference-in-differences approach.

Another concern on the validity of estimated announcement and implementation effects of water price increase is the choice of control group, as private apartment households may also respond to the water price increase, leading to biased estimate on the effects on HDB flats. To address this concern, we construct two alternative control groups using non-residential water consumers. We identify two industry groups with low incentive to respond to the water price increase: (1) Short-term accommodation: where water use is mostly for residential purpose, but the water users do not pay for water bill directly; (2) Industries with very low water consumption dependency (refer to Supplementary Table 8 for detail): where the cost of water constitutes a very small proportion of

the production and operation of the industry. As shown in Supplementary Figure 4, the change in water consumption after the water price increase is not graphically visible in both the short-term accommodation and low water dependency groups. We find no statistically significant changes in water consumption after the announcement and implementation of water price increase relative to the pre-announcement time for the two groups of industry water users using RDIT (Supplementary Table 7). Lastly, using a difference-in-differences approach, we find no evidence of statistically significant changes in water consumption after the announcement/implementation of water price increase for private apartments, comparing to the two industry groups. For HDB flats, on the other hand, the reduction in water consumption after price increase remains statistically significant relative to the industry groups (Supplementary Table 8).

More about the announcement effect: The relatively large announcement effect is likely due to the increased public attention primed by the policy communication. Between the time of policy announcement and its implementation, consumers do not bear the financial burden of the water price hike. However, the announcement, along with the subsequent information provision via state newspapers and various social media platforms has elicited significant attention from the population. There is not only passive absorption of information, but also active search of related information. As shown in Figure 2(a), the number of Google searches on “water price” reached its highest in a decade in February 2017, when the price increase was announced. We expect this heightened public attention on water price brought by the policy announcement to change consumer behavior.

Although we are not able to provide direct evidence on whether the announcement effect is a result of information or anticipation of price increase, we provide some insights through the heterogenous analysis. Firstly, if the announcement effect is driven by information, we would

expect heterogeneous effect across population groups with different baseline understanding of price information. Literature has shown that consumers with low water demand tends to pay less attention on water price and is more likely to mis-estimate the cost of using water.¹³ We therefore divide our sample into quartiles by households' baseline water consumption and estimate heterogeneous announcement effect (equation (6) in Methods). We find the announcement effects to decrease from a 4.8% ($P < 0.001$, 95% CI [-0.07, -0.03]) reduction in water consumption for consumers with the lowest quartile of water demand to 2.5% ($P = 0.004$, 95% CI [-0.04, -0.01]) for consumers with the highest quartile of water demand (Figure 3(a)). Similarly, we find the announcement of price increase to be more effective in reducing water consumption for households with relatively low water demand regardless of household income (Supplementary Figure 5).

Secondly, if the announcement effect is due to anticipation, we would expect the users with high water demand to respond more to the announcement as the increase in the water bill is expected to be larger for this group. As shown in Figure 3(a), such trend does not hold for announcement effects. On the other hand, we observe more reduction in water consumption for large water users after the implementation of water price increase, which is consistent with our expectation. As shown in Figure 3(b)-(c), we find the implementation of price increase to have the largest effect on consumers in the highest quartile of water demand (quartile 4), with 3.8% ($P < 0.001$, 95% CI [-0.06, -0.02]) and 5.6% ($P < 0.001$, 95% CI [-0.07, -0.04]) reduction after the first and second price increase respectively, comparing to 0.72% ($P = 0.46$, 95% CI [-0.03, 0.01]) and 0.14% ($P = 0.86$, 95% CI [-0.02, 0.01]) for consumers with the lowest quartile of water demand. This implies that the announcement effect is not solely driven by the anticipation of price increase.

Thirdly, the announcement effect through anticipation is likely to have a larger impact on low-income families who are more sensitive to price change. To understand the effect of price increase

by income group, we estimate the heterogenous effect by HDB flat type (equation (6) in Methods), a proxy for income level, and find no clear trends in the announcement across HDB flat type (Figure 3(d)). Additionally, we do not find any evidence that low-income households respond more to the announcement of price increase, despite the levels of water consumption (Supplementary Figure 5). This provides more evidence that anticipation of price increase plays a limited role in determining the announcement effect.

Welfare implications: Although pricing policy is effective in reducing water consumption and the announcement of price increase could further enhance its effectiveness, one major concern remains as leveraging water price to manage residential water demand may be regressive. Our heterogenous analysis shows no statistically significant differences in the effect of announcement as well as the first and second price increases across HDB flat type (Figure 3(d)-(f)). However, based on the estimated changes in water consumption by flat type, we find that the change in water bill as a percentage of income is larger for households with relatively low income (Figure 4(a)).

Effect of utility subsidy increase

Policy background: The utility subsidy in Singapore is distributed through Goods and Services Tax Voucher - Utility-Save (GST Voucher - U-save). It aims at helping lower- to middle-income households offset utility bills. To be eligible for the program, a household must reside in an HDB flat, with at least one Singaporean occupier and none of the household members should have interests in more than one property. The subsidy is credited automatically at the beginning of each quarter to the utility accounts of qualified households without any sign-up requirement and the utility bills are adjusted automatically. The unused amount can be carried over until account closure but cannot be withdrawn. The amount of subsidy is determined by HDB flat size, in

accordance with their respective income levels (Supplementary Table 8).

To address the regressive distributional effect, alongside the water price increase, Singapore government also announced, in February 2017, an increase in the utility subsidy to take effect in July 2017. The amount of increase in subsidy, ranging from S\$10 per quarter for HDB Executive flats to S\$30 per quarter for HDB 1-room flats, is larger for households with lower income. As shown in Figure 4(b), this increase is sufficient to cover the average change in water bill for HDB 1-room to 3-room flats, based on the estimated changes in water consumption by flat type (Figure 3(d)-(f)), after the implementation of the two-stage price increase. As a result of the increase in utility subsidy, the net cost of water as a proportion of income for low-income households has also been reduced (Figure 4(c)). These observations show that utility subsidies could be effective in reducing the regressivity of pricing policies. However, an increase in utility subsidy also reduces the average costs of water, which may in turn increase its consumption.

As we are unable to separately estimate the effect of price and subsidy increases that were implemented simultaneously in 2017, we focus on the subsidy increases implemented in 2012 to provide some insights on consumption responses to subsidy increase.

Intent-to-treat effect: The 2012 subsidy increase, ranging from \$20 to \$35 per quarter by HDB flat type, was announced in February and implemented in July. The baseline sample we use to evaluate the effect of this subsidy increase is from January 2011 to December 2013. We use a difference-in-differences approach to compare the water consumption before and after the announcement and implementation of subsidy increase for HDB flats, relative to private apartments, by estimating equations (3) and (4). In 2019, 84% of all HDB flats received utility subsidy. However, we do not have information on household level eligibility status and our

estimates should be viewed as an intent-to-treat effect.

As shown in Table 1 Column (3), we find no statistically significant change in water consumption for HDB flats in response to the announcement of subsidy increase (0.5%, $P=0.698$, 95% CI [-0.02, 0.03], $BF_{10}=0.0001$). We further show in Table 1 Column (4) that there is no statistically significant effects of either the announcement (0.6%, $P=0.646$, 95% CI [-0.02, 0.03], $BF_{10}=0.0002$) or implementation of subsidy increase (0.6%, $P=0.520$, 95% CI [-0.01, 0.03], $BF_{10}<0.0001$), nor the combination of the two (1.2%, $P=0.49$, 95% CI [-0.02, 0.05], $BF_{10}<0.0001$). These results are robust to alternative specifications (Supplementary Table 10) and across income groups and water demand levels (Figure 5).

In 2019, a \$5 increase per quarter in utility subsidy was given across all HDB flat types. As the time frame for the 2019 subsidy change, announced in February 2018 and implemented in January 2019, overlaps with that of the water price increase (July 2017 and 2018), the water consumption trend for the HDB flats might have changed because of the water price increase and the parallel trend assumption for the difference-in-differences for this analysis might be violated. Although we attempt to mitigate this concern by including group-specific time trend, the evaluation on the effect of the 2019 subsidy increase is less rigorous and is shown in the Supplementary Table 10. Nonetheless, similar to the findings on the 2012 subsidy increase, we find no credible evidence that households respond to the announcement and implementation of subsidy increases.

Mechanism: The underlying mechanism for the null effect of subsidy could provide important lessons for protecting the vulnerable groups from environmental/social policies in the pursuit of sustainable growth. One possible explanation for the null effect is the low public attention to the subsidy program due to its design. GST Voucher – U-save is framed as a rebate, which is perceived

as a forgone loss hence elicit less attention and behavior responses.²⁸ Moreover, it has no sign-up requirement, is automatically credited to the utility account for eligible households, and is applied to offset their utility cost with no individual actions required. The lack of action²⁷ significantly reduces the attention to the subsidy and the consumption responses. The inattention hypothesis is further backed up by the low number of Google searches on utility subsidy (“U-save”) relative to “water price” (Figure 2(a)) and other components of the GST Voucher scheme, such as GST Voucher – Cash, which requires active usage (Figure 2(b)). The changes in the number of searches around the announcement and implementation of the subsidy increase are also minimal, which indicates the lack of attention on utility subsidy.

We further test alternative explanations for the null effect. Firstly, the null result is not due to small sample size. Our sample includes 95% of the households (2.2 million) in the country with a minimal detectable effect size of 0.07% at 95% confidence interval with 80% power, smaller than all estimates across various models. Secondly, the null effect is not due to small amount of subsidy increase. Although the 2019 subsidy increase was small, the increase in 2012 was larger than the estimated change in water bill led by the price increase (Supplementary Figure 6). Thirdly, we find no credible evidence of a delayed response as the null effect is persistent over time (Supplementary Figure 9) nor is there any evidence of the timing of subsidy disbursement (i.e., beginning of each quarter) affecting the results (Supplementary Figure 10). Lastly, the null effect is unlikely due to the increase in subsidy and dispensable income being used for other household items as we find no evidence of the subsidy increase affecting household’s electricity consumption or grocery expenses (Supplementary Table 13).

Discussion

In this study, we show that improving the announcement of water price increase enhances the effectiveness of pricing policies on residential water consumption. Using anonymous monthly billing data on residential water use for 95% of all households in Singapore over 10 years, we show that the 30% increase in water price reduces monthly water consumption by 5.8% more for an average HDB flat, relative to private apartments. The announcement of the price increase alone contributes to a 3.7% decline in water consumption, accounting for 64% of the overall effects. We find that consumers who are less attentive to water price information respond more to the announcement of water price increase. This finding, consistent across income groups, further corroborates the role of information provision in altering price elasticity. Meanwhile, we find that with calibrated program design, utility subsidies could reduce the disproportionate burden on low-income households without reversing the water conservation achieved through price increase.

Compared to alternative demand management initiatives, combining traditional market-based policy tools, such as water pricing and utility subsidy, with information dissemination could be more cost-effective in reducing residential water consumption. Research has shown that a nationwide peer comparison had no statistically significant effect on water consumption for an average household in Singapore and nationwide efficiency improvements of water fittings reduced water consumption by 3.5%.³⁵ The implementation of this combination of policies also had minimal requirement on technology advancement and institutional innovation, as compared to many proposed solutions to urban water challenges.³⁶

The findings on the role of information have broader implications on the implementation of market-based conservation and environmental policies. E-payments and automatic deduction of utility bills are becoming increasingly popular, which further reduces attention to price changes. Policy makers and utility managers should consider the potential challenge this may impose on

water and energy demand management. Countries that leverage carbon tax and trading to mitigate the impact of climate change could similarly benefit from policy designs that utilize the price information provision to improve its effectiveness.

Limitations: There are some caveats to be considered. Firstly, to evaluate the effect of price change, we use private apartments as the control group although the water price increase is nationwide and applies to private apartment households as well. The estimated effects should therefore be considered as the additional effect on HDB flats, instead of the full price effect, even though we find no credible evidence of a discontinuity in water consumption for private apartments before and after the price increase. Secondly, as we cannot identify the 84% of HDB flats that receive the utility subsidy, we are only able to estimate the intent-to-treat effect. The average treatment effect on the eligible households and spillover effects, if any, on the non-eligible HDB flats remain unclear. Lastly, as the announcement and implementation of water price increase was accompanied by a simultaneous subsidy increase, we are unable to directly separate the effects of the two. As there is a lack of consumer responses to other changes in utility subsidies, the effect of price increase is less likely contaminated. However, if households responded to the subsidy increase differently when combined with a price increase, the price effect may be underestimated.

Methods

Data

The main data we use for this study is anonymized monthly water consumption by account obtained from PUB, Singapore's national water agency. The dataset contains 126,123,832 observations of monthly water consumption based on water bills for 2,231,379 unique accounts, which covers all non-landed residential premises that houses 95% of the country's resident

households, from January 2011 to December 2019. Meter-reading is conducted approximately every two months in Singapore. Water consumption for the month without meter-reading is estimated using the previous two meter-readings. We exclude extreme values of the top and bottom 1% observations for each premise type to account for potential measurement errors caused by water leakage or problematic meter-readings.

The dataset includes anonymized account numbers that change every time a household moves, block identifier/postal code, property type (HDB vs private apartments) and HDB flat type classified by the number of rooms (1-5 room flats and HDB executive flats). In our data, private apartments account for 20.1% of all accounts with a mean monthly water consumption of 15.6 m³. Note that this is the mean water consumption of all private apartments of various sizes. Among the HDB flats, the monthly water consumption averages between 11.2 m³ for HDB 1/2-room flats and 20.5 m³ for the executive flats. Supplementary Figure 11 presents the distribution of accounts by flat type and their corresponding mean monthly water consumption.

As shown in Supplementary Table 14, the mean monthly water consumption reduced from 17.3 m³ to 15.4 m³ for HDB flats and from 16.3 m³ to 14.3 m³ for private apartments.

Empirical method

Empirical analysis in this paper is conducted using Stata 17. All test statistics are two-sided. Data distribution is assumed to be normal, but this is not formally tested.

To analyze the effect of water price and utility subsidy change on residential water consumption, we use a difference-in-differences regression approach with HDB flats as the treatment group and private apartments as the control group. However, the change in water price affects the entire population, including the control group. Our empirical estimation therefore relies on the

assumption that households in private apartments do not respond to water price change the same way as the HDB flats. We start our empirical analysis by verifying this assumption.

Regression Discontinuity in Time

If households respond to the water price increase, we will observe a discontinuity in residential water consumption before and after its announcement or implementation. If the price change effects vary by property type (i.e., private vs HDB) as we hypothesize, the discontinuity in water consumption should also differ. Therefore, we first use a Regression Discontinuity in Time (RDIT) approach to formally evaluate the effect of price changes on the HDB flats and private apartments, respectively.

We use observations from January 2015 to December 2018 for private apartments and HDB flats as the respective baseline sample. We estimate the following equation:

$$\ln W_{it} = \beta \text{PostAnnouncement}_t + f(t) + \alpha_i + \gamma_{t(m)} + \epsilon_{it} \quad (1)$$

The dependent variable is the natural logarithm of monthly water consumption plus one for account i in time period t . $\text{PostAnnouncement}_t$ is the indicator variable which takes the value of 1 for time periods after the announcement of price change in February 2017. $f(t)$ is a function of the running variable, which is time in our case. We use a first-degree polynomial and allow the slope to vary across the discontinuity. We include account fixed effects α_i to account for time-invariant household characteristics. We address the concern of seasonal or cyclical variation in water consumption by including month fixed effects $\gamma_{t(m)}$.

The coefficient of interest β measures the changes in water consumption before and after the announcement of price increase. We expect the coefficient to be statistically insignificant for the

private apartments, providing some suggestive evidence that the price increase does not alter water consumption for this group.

We further divide the post-announcement period into three time-windows, namely announcement (March to July 2017), first price increase (August 2017 to July 2018), and second price increase (August 2018 to December 2018), to compare the water consumption in each time window with that of the pre-announcement period. We estimate the follow equation:

$$\ln W_{it} = \beta_1 \text{Announcement}_t + \beta_2 \text{FirstIncrease}_t + \beta_3 \text{SecondIncrease}_t + f(t) + \alpha_i + \gamma_{t(m)} + \epsilon_{it} \quad (2)$$

where *Announcement*, *FirstIncrease* and *SecondIncrease* are indicator variables that take the value of 1 for each respective time windows. The coefficients β_1 , β_2 , and β_3 measure the difference in water consumption between each time window and the pre-announcement baseline.

As a robustness check, we use a semi-balanced sample or accounts with observations at least two months before the cutoff as an alternative sample. This is to address the concern of covariate balance and sorting in RDIT design. Other robustness checks include alternative specifications, such as varying the fix effects included and adding environmental/weather controls to account for spatial variations in temperature, rainfall, and air pollution; and use alternative bandwidth, i.e., evaluating the effect on bi-monthly water consumption instead of monthly.

Difference-in-differences analysis

We first investigate the overall effect of the price and subsidy change considering its announcement as the timing of treatment. For the water price change, although it was implemented in two stages, the announcement was made in February 2017. Therefore, in our baseline model, we consider January 2015 to February 2017 (26 months) to be the pre-announcement period and

March 2017 to December 2018 (22 months) to be the post-announcement period. Similarly, for the subsidy change announced in 2012, we consider January 2011 to February 2012 (14 months) as the pre-announcement period, and March 2012 to December 2013 (22 months) as the post-announcement period.

To evaluate the overall effect of price and rebate change, we estimate the following specification:

$$\ln W_{it} = \delta_1 Pre_t \times HDB_i + \delta_2 PostAnnouncement_t \times HDB_i + \theta_k \tau + \alpha_i + \gamma_t + \epsilon_{it} \quad (3)$$

where Pre_t is an indicator variable that takes the value of 1 for the six months before the announcement of price or rebate change. $PostAnnouncement_t$ is the indicator variable which takes the value of 1 for time periods after the announcement of price or rebate change and HDB_i is an indicator variable for the treatment group, i.e., HDB flats. We allow the two groups to have different water consumption trend by including group-specific linear time trend τ . We include account fixed effects α_i to account for time-invariant household characteristics and time fixed effect γ_t to account for seasonality and other economy-wide common shocks. The standard errors are two-way clustered by block and year-month. The coefficient of interest δ_1 and δ_2 measures the differences in monthly water consumption for the treatment group relative to the control group before and after the announcement of price or rebate change.

As we are particularly interested in how information and policy announcement modify the effect of price and rebate change, we differentiate the effect of announcement and implementation by estimating the following equation:

$$\begin{aligned} \ln W_{it} = & \delta_1 Pre_t \times HDB_i + \delta_2 PostAnnouncement_t \times HDB_i \\ & + \sum_n^N \delta_{3n} PostImplementation_t \times HDB_i + \theta_k \tau + \alpha_i + \gamma_t + \epsilon_{it} \end{aligned} \quad (4)$$

Specifically, $PostAnnouncement_t$ is an indicator variable that equals 1 for the time periods after the announcement of policy change; while $PostImplementation_t$ is an indicator variable that takes the value of 1 for the time periods after the actual policy change. N is the total number of stages a policy is implemented in, which is one for 2012 rebate change and two for 2017/18 price change.

The coefficient of interest δ_2 captures the average effect of the announcement on the water consumption for the treatment group, relative to the control group. The coefficients $\delta_{3n}(s)$ capture the additional effects of each phase of the subsidy/price increase. Note that the announcement of price change in February 2017 and the first stage of price increase in July 2017 are accompanied by an announcement and implementation of subsidy increase, therefore the corresponding coefficients measure a combined effect of price and subsidy change.

For robustness checks, we use alternative specifications such as excluding group specific time trend, including weather and pollution controls, controlling for block fixed effects instead of account fixed effects and lastly, controlling for year fixed effects and month fixed effects instead of year-month fixed effects. We also consider alternative samples, such as including observations with the top and bottom 1% of monthly water consumption and use alternative sample periods. To evaluate the effect of price change, we consider sample periods from January 2011 to December 2018, from January 2015 to December 2019 as well as the full sample of January 2011 to December 2019. To evaluate the effect of 2012 rebate change, we consider extending the sample periods to December 2016.

There was another utility subsidy increase announced in February 2018 that took effect in January 2019. As the timeline overlapped with the second water price increase, we are unable to estimate the overall effect of the subsidy change as cleanly as the 2012 rebate change. To overcome this

estimate challenge, we estimate the following models: First, to capture the effect of announcement, we estimate equation (2) using sample period of August 2017 (after first price increase) to July 2018 (before second price change) with the indicator variable *PostAnnouncement* taking the value of 1 for time periods after February 2018 or the announcement of rebate change. Second, to evaluate the effect of the implementation of subsidy increase, we estimate an equation similar to equation (2) using sample period from Aug 2018 (after the second price change) to April 2019, with the policy change indicator taking the value of 1 for time periods after January 2019. Lastly, we use the sample from August 2017 (after the first price increase) to December 2019 and estimate equation (3). We include two separate *PostImplementation* indicators, one for the time periods after then second price increase and one for the time periods after the subsidy change in January 2019.

Evolutionary effect

We conduct event studies to estimate a non-parametric model that fully illustrates the evolutionary effect of price and subsidy change.

We consider the following equation:

$$\ln W_{it} = \sum_{j=-T}^T \delta_j D_t \times HDB_i + \theta_k \tau + \alpha_i + \gamma_t + \epsilon_{it} \quad (5)$$

where we interact the treatment indicator with the set of time dummies D_t that takes the value of 1 for time-period t . The coefficient of interest δ_0 shows the immediate effect of the policy announcement and coefficients δ_1 to δ_T measure the effect on consumption in each quarter post the announcement of price/subsidy increase, while the coefficients δ_{-T} to δ_{-1} measure the difference in water consumption between the treatment and control group in each quarter of the pre-announcement time-period.

Heterogeneous effect

We study the heterogeneous responses to the announcement and implementation of price and subsidy change by various groups of individuals (e.g. different levels of water consumption, HDB flat type, and the combination of the two) using the following specification:

$$\ln W_{it} = \sum_{m=-1}^M \delta_m PostAnnouncement_t \times HDB_i \times G_i + \sum_{n=1}^N \sum_{m=-1}^M \delta_{nm} PostImplementation_t \times HDB_i \times G_i + \theta_k \tau + \alpha_i + \gamma_t + \epsilon_{it} \quad (6)$$

where M is the number of subgroups we decompose into and G_i is subgroup indicator. Recall that N is the number implementation stages. The coefficients δ_1 to δ_m measure the heterogeneous response to announcement effects while coefficients δ_{n1} to δ_{nm} capture effects of the implementation of price and subsidy increase.

Data availability statement

The water consumption data for this study is provided by PUB, Singapore's National Water Agency under non-disclosure agreement for the current study. Upon reasonable request to PUB and with the necessary non-disclosure agreements signed with NUS, it is available onsite at NUS to replicate all the results from the deposited Stata code.

Code availability statement

Stata code used for data analysis in this study is available at <https://github.com/mingxuanfan/waterprice>.

Acknowledgements

All the authors acknowledge the funding and water consumption data support from the PUB, Singapore's National Water Agency. The funder had no role in study design, data analysis, decision to publish or preparation of the manuscript. Research reported in this publication was supported by the Institute for

Environment and Sustainability, at the Lee Kuan Yew School of Public Policy, National University of Singapore.

Contribution

All authors contributed to the research design, implementation, data analysis and writing.

Conflicts of interests

The authors declare no competing interests.

Figures and Tables

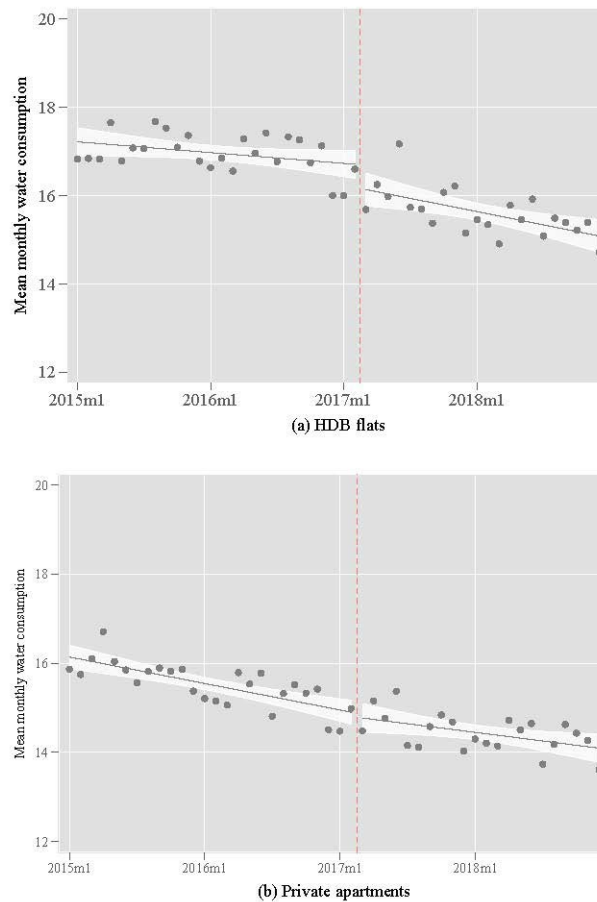
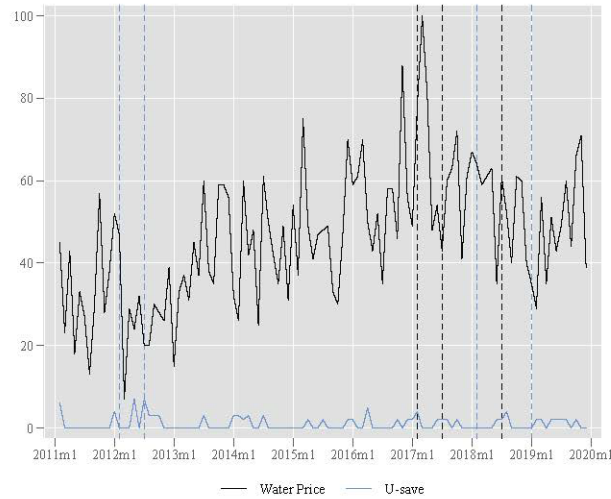
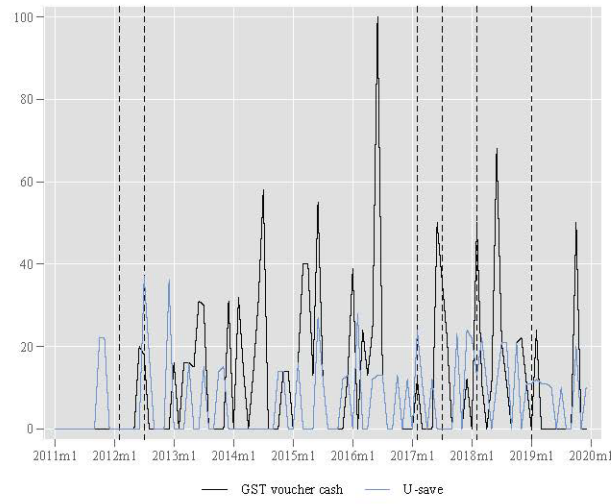


Figure 1: Graphical analysis of regression discontinuity. The figures show linear trends in monthly water consumption before and after the announcement of water price increase (February 2017 as indicated by vertical dotted lines) for HDB flats (sub-figure (a)) and private apartments (sub-figure (b)) respectively. The white areas represent the 95% confidence interval, and the dots show the monthly mean water consumption.



(a) Water price and U-save



(b) GST Voucher Cash and U-save

Figure 2: Google search on price and rebate change. The figures present the Google Search Index on water price, u-save and GST Voucher Cash. In subfigure (a), the month with the highest number of searches on water price is indexed as 100. The black vertical lines indicate the timing of the announcement (February 2017) and implementation (July 2017 and July 2018) of the price increase. The blue vertical lines indicate the timing of announcement (February 2012 and February 2018) and implementation (July 2012 and January 2019) of the increase in GST Voucher – U-save. In subfigure(b), the month with the highest number of searches on GST Voucher Cash is indexed as 100. The vertical lines indicate the timing of the announcement (February 2012, February 2017, and February 2018) and implementation (July 2012, July 2017, and January 2019) of the increase in GST Voucher Cash.

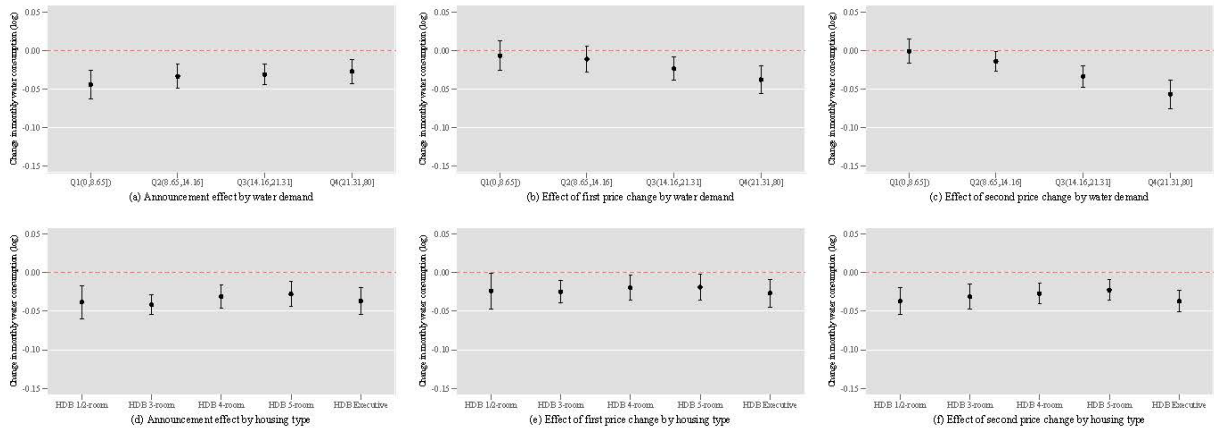
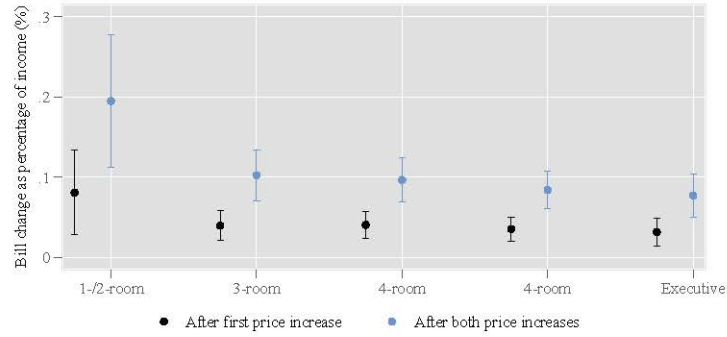
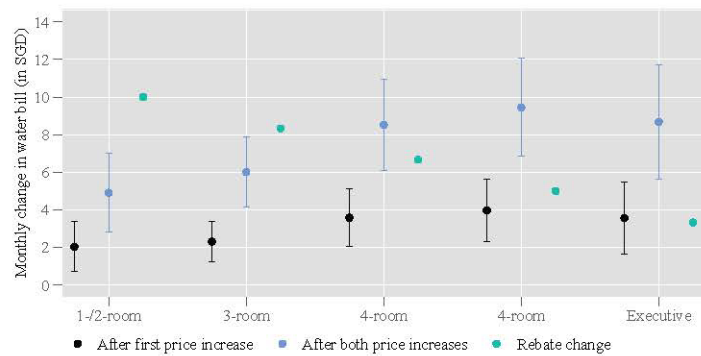


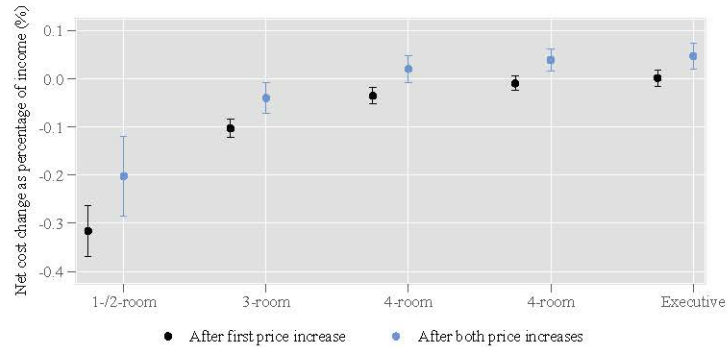
Figure 3: Heterogeneous responses to price change. The figures show the effects of announcement, first and second price increase by baseline water demand (sub-figures (a)-(c)) and flat type (sub-figures (d)-(f)). The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6) using 56,953,157 observations from January 2015 to December 2018. Standard errors are clustered by block and year-month.



(a) Bill change as percentage of income



(b) Bill change and rebate change



(c) Net cost of water as percentage of income

Figure 4: Distributional effect of price increase. The figures show the estimated changes in water bill (dots) and the corresponding 95% confidence intervals (error bars) after each price increase by HDB flat types. The percentage changes in water consumption by flat type are estimated using equation (6) using 56,953,157 observations from January 2015 to December 2018. Subfigure (a) presents the change in water bill as a percentage in income, subfigure (b) compares the change in water bill to the change in subsidy, while subfigure (c) presents the change in the net cost of water as percentage of income.

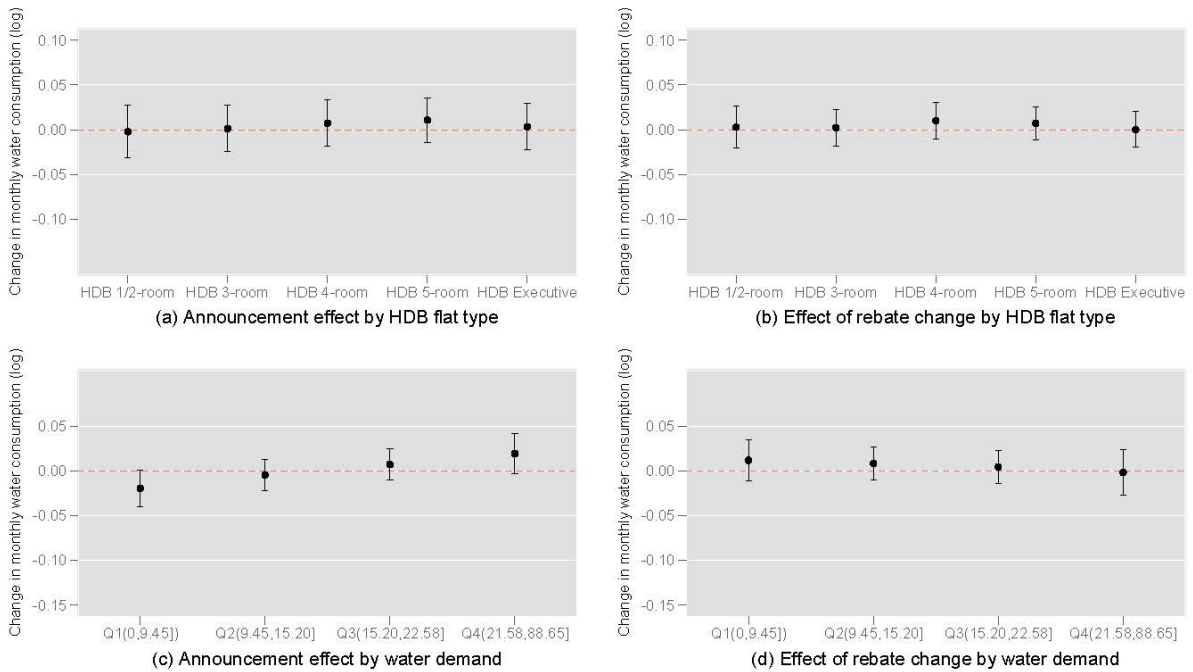


Figure 5: Heterogeneous responses to subsidy increase. The figures show the effects of announcement and subsidy increase in 2012 by HDB flat type (sub-figures (a) and (b)) and baseline water demand (sub-figures (c) and (d)). The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6) using 37,368,269 observations from January 2011 to December 2013. Standard errors are clustered by block and year-month.

Table 1: Effect of price and subsidy increase on water consumption

Dependent variable:	(1)	(2)	(3)	(4)
Log of water consumption	Price increase		Subsidy increase	
Pre*HDB	-0.007	-0.007	0.004	0.006
<i>Standard error</i>	(0.006)	(0.006)	(0.008)	(0.010)
<i>t-statistics</i>	-1.21	-1.22	0.53	0.67
<i>P-value</i>	0.231	0.230	0.598	0.507
<i>95% CI</i>	[-0.018,0.005]	[-0.018,0.005]	[-0.013,0.021]	[-0.013,0.026]
Post announcement*HDB	-0.058***	-0.037***	0.005	0.006
<i>Standard error</i>	(0.006)	(0.008)	(0.012)	(0.013)
<i>t-statistics</i>	-9.88	-4.65	0.39	0.46
<i>P-value</i>	<0.001	<0.001	0.698	0.646
<i>95% CI</i>	[-0.070, -0.047]	[-0.054, -0.021]	[-0.020,0.030]	[-0.019,0.032]
Post first price increase*HDB		-0.021***		
<i>Standard error</i>		(0.008)		
<i>t-statistics</i>		-2.73		
<i>P-value</i>		0.009		
<i>95% CI</i>		[-0.037, -0.006]		
Post second price increase*HDB		-0.028***		
<i>Standard error</i>		(0.007)		
<i>t-statistics</i>		-4.20		
<i>P-value</i>		<0.001		
<i>95% CI</i>		[-0.042, -0.015]		
Post subsidy increase*HDB				0.006
<i>Standard error</i>				(0.010)
<i>t-statistics</i>				0.65
<i>P-value</i>				0.520
<i>95% CI</i>				[-0.013,0.026]
Group time trend	Yes	Yes	Yes	Yes
Account FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
N	56,953,157	56,953,157	38,381,985	38,381,985
R ²	0.773	0.773	0.784	0.784

This table presents the effect of price and subsidy increase on the water consumption for the HDB flats, relative to private apartments. The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is January 2015 to December 2018 for columns (1) and (2); January 2011 to December 2013 for columns (3) and (4). Columns (1) and (3) show the average effect of price change and 2012 subsidy change by estimating equation (3); Columns (2) and (4) show the decomposed effects by estimating equation (4). *HDB* is an indicator variable that takes the value of 1 for HDB flats or treatment group. *Pre* is an indicator variable taking the value of 1 for the six months before the announcement of price and subsidy change. *Post announcement*, *Post first price increase*, *Post second price increase* and *Post subsidy increase* are indicator variables equal 1 for time periods after the corresponding event. All models include group-specific time trend, account fixed effects and year-month fixed effects. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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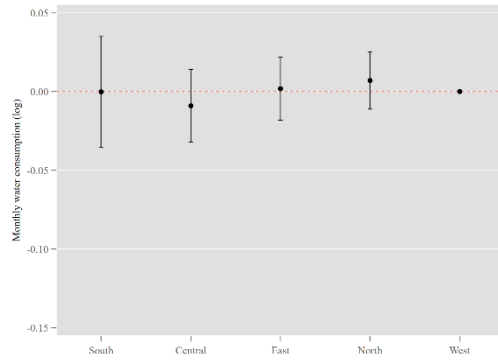
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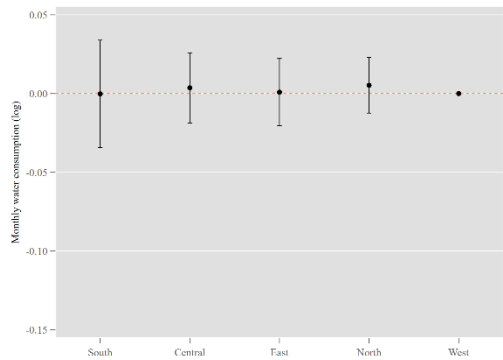
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Supplementary Information

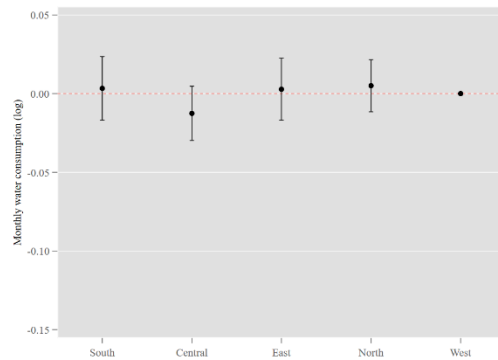
Supplementary Figure 1: Differences in the responses to price change by region



(a) Announcement effect by region



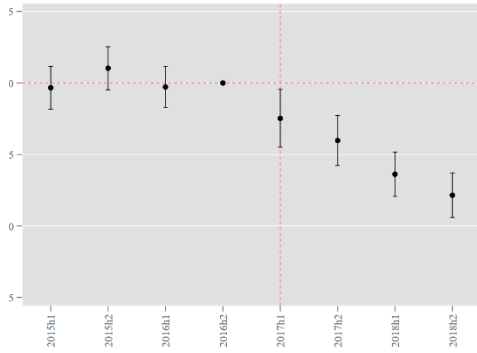
(b) Effect of first price increase by region



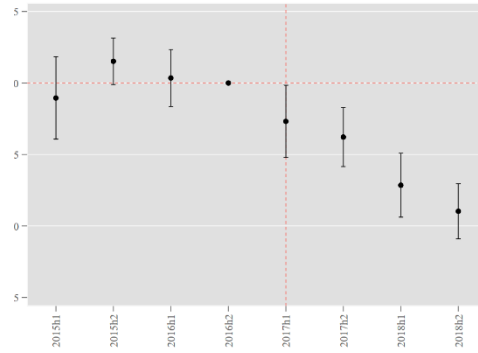
(c) Effect of second price increase by region

Note: The figures show the differences in effects of the announcement (sub-figure (a)), first price increase (sub-figure (b)), and second price increase (sub-figure (c)) cross various regions in Singapore, relative to the West Region. The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6) using 56,953,157 observations from January 2015 to December 2018.

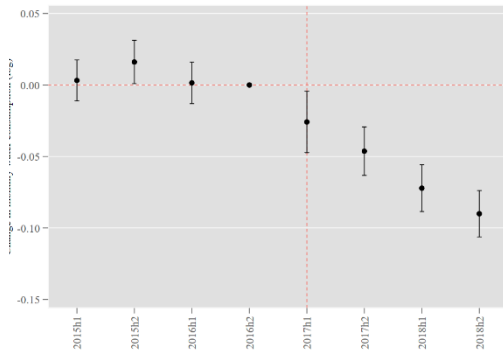
Supplementary Figure 2: Evolutionary effect of price increase



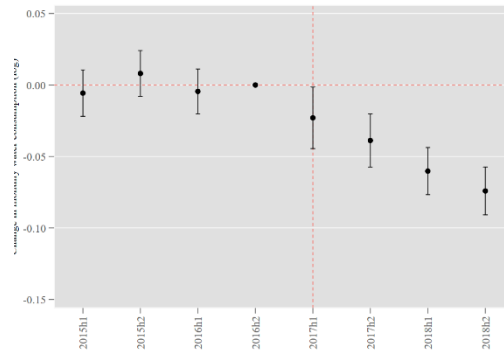
(a) overall



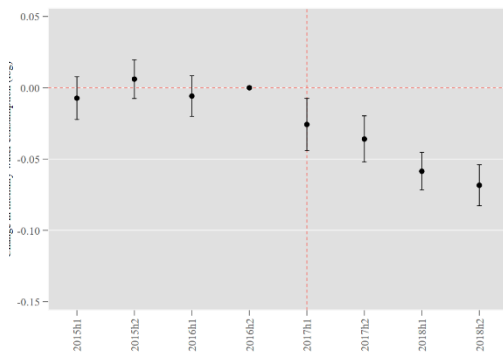
(b) HDB 1-/2-room



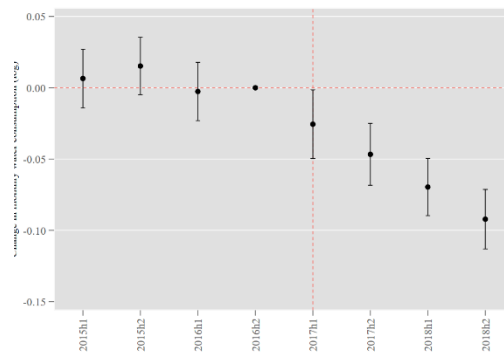
(c) HDB 3-room



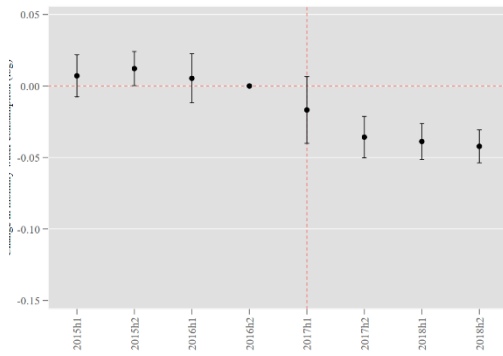
(d) HDB 4-room



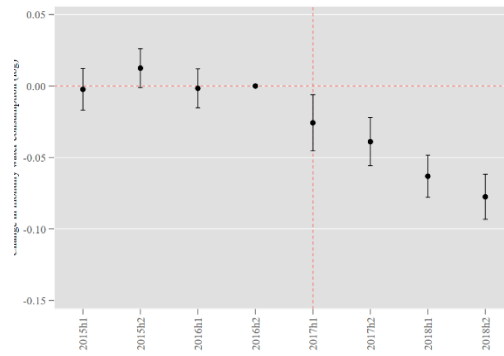
(e) HDB 5-room



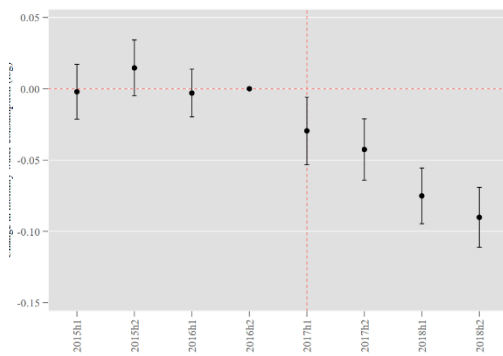
(f) HDB Executive



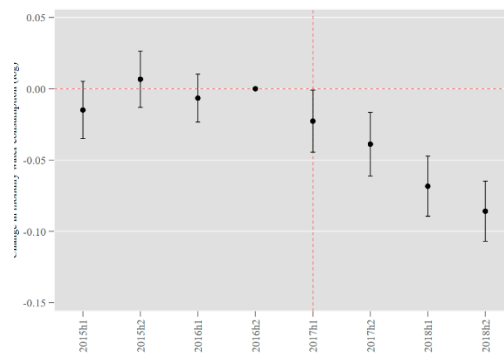
(g) Quartile 1



(h) Quartile 2



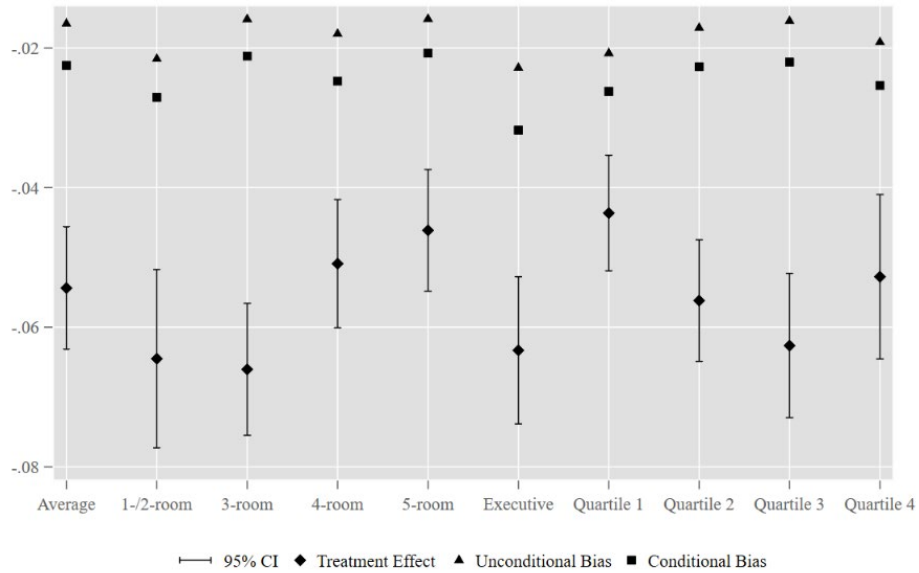
(i) Quartile 3



(j) Quartile 4

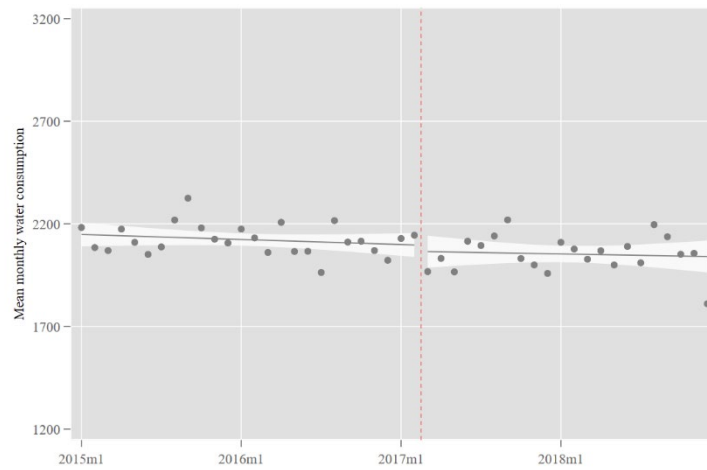
Note: The figures show the differences in water consumption between the control and treatment group before and after the announcement of price increase for the baseline sample (sub-figure (a)), by HDB flat types (sub-figures (b) to (f)) and by baseline water demand (sub-figures (g) to (j)). The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (5) 56,953,157 observations from January 2015 to December 2018. The vertical line indicates the timing for the announcement of price increase.

Supplementary Figure 3: Test on the Potential Effects of Pre-trend

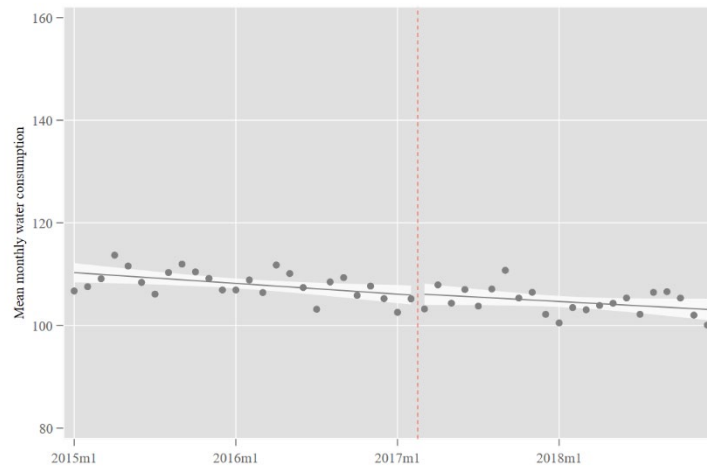


Note: The figure shows the linear violation of parallel trends that conventional pre-trends tests would detect 80% of the time. The squares show the bias that would result from such a trend conditional on passing the pre-test; the triangles show the unconditional bias from such a trend. As a benchmark, we show the coefficients (diamonds) and corresponding 95% confidence intervals (error bars) for the difference in water consumption between the control and treatment group before and after the announcement of price increase, by estimating equation (5), using 56,953,157 observations from January 2015 to December 2018, for the overall sample and each sub-groups by HDB type and baseline water consumption level.

Supplementary Figure 4: Graphical analysis of regression discontinuity



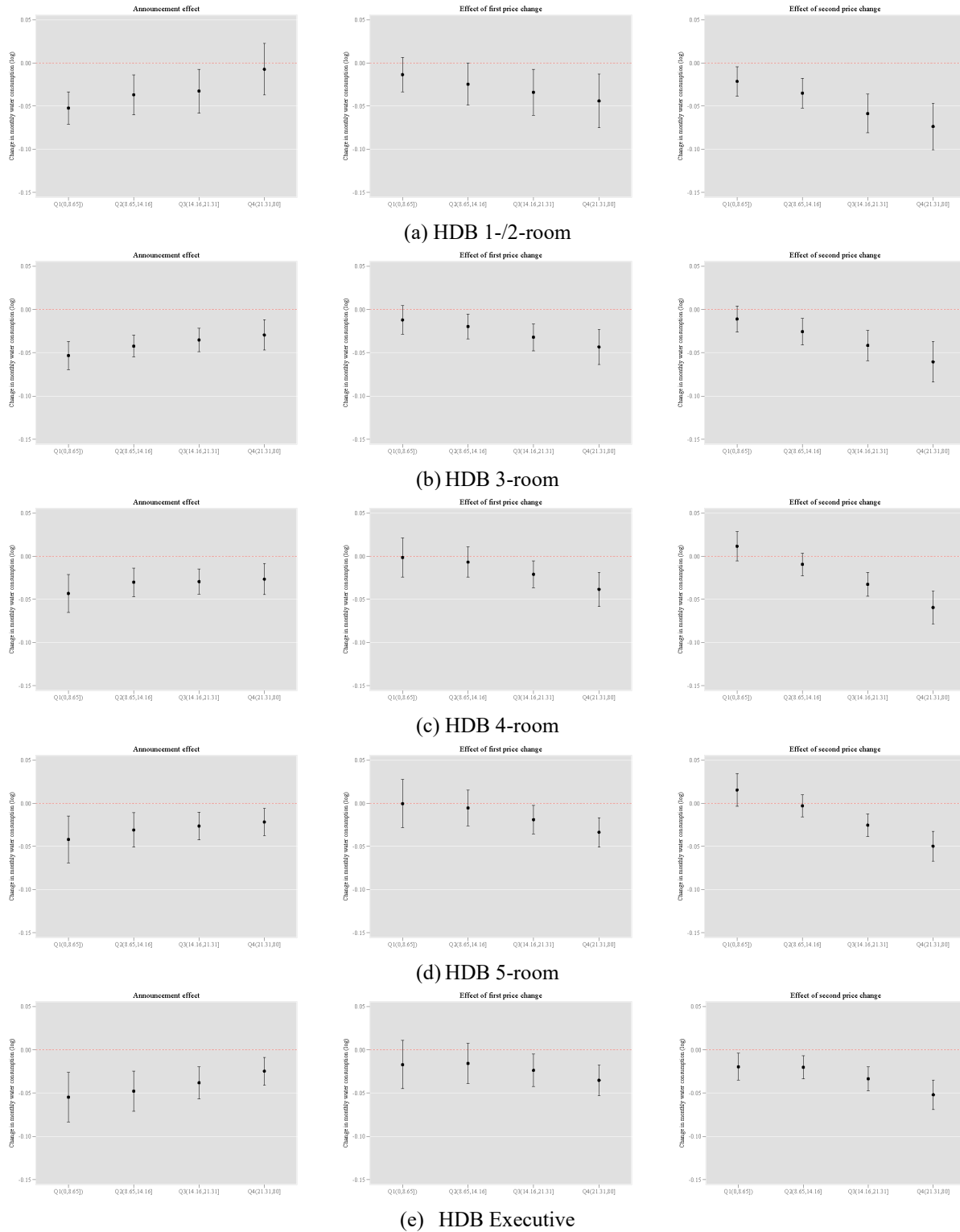
(a) Short-term accommodation



(b) Industries with low water dependency

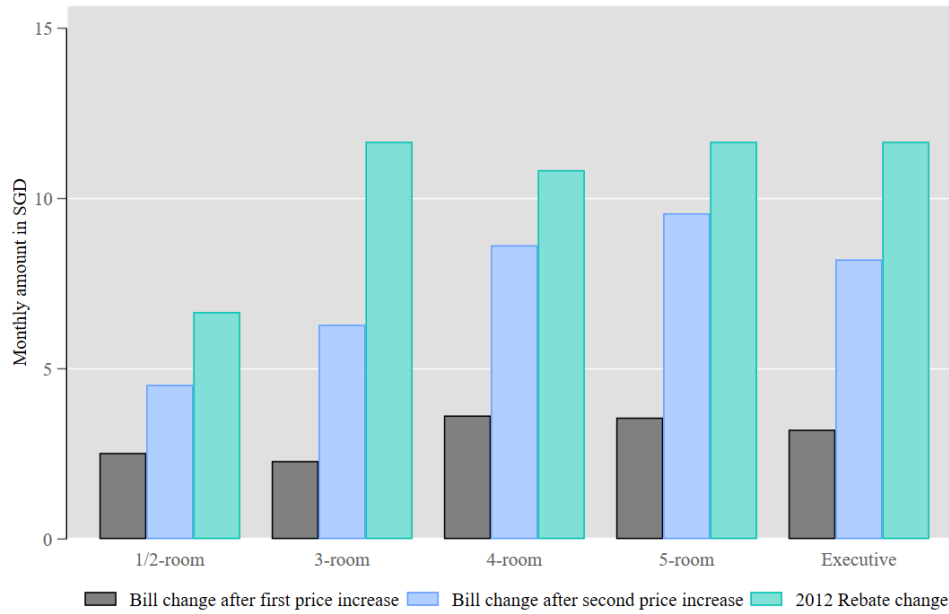
Note: The figures show the linear trends in monthly water consumption before and after the announcement of water price increase (February 2017 as indicated by vertical dotted lines) for short-term accommodation industry and industries with low water consumption dependency respectively. The white areas represent the 95% confidence interval, and the dots show the monthly mean water consumption.

Supplementary Figure 5: Heterogeneous responses to price change by HDB type and water consumption quartile



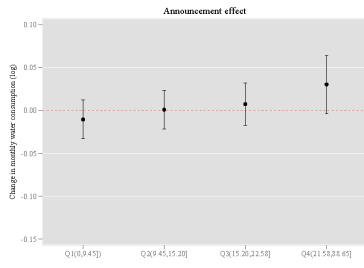
Note: The figures show the effects of announcement, first price increase, and second price increase by water consumption quartile for each HDB flat type. The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6) using 56,953,157 observations from January 2015 to December 2018.

Supplementary Figure 6: Amount of subsidy increase in 2012

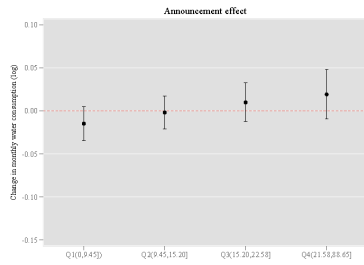
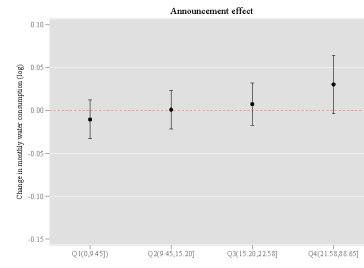


Note: The figure compares the estimated change in water bill after the price increases with the 2012 subsidy increase by HDB flat types.

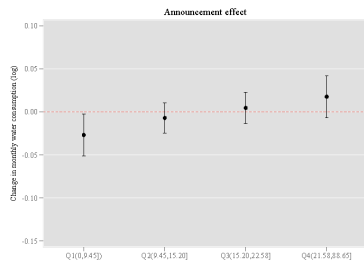
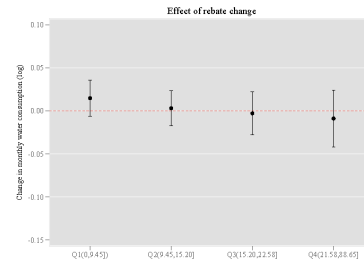
Supplementary Figure 6: Heterogeneous responses to 2012 subsidy increase by water consumption quartile for each flat type



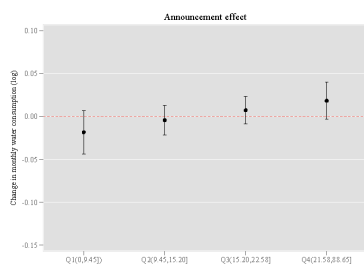
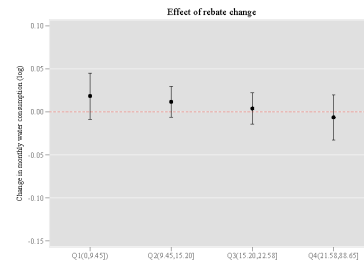
(a) HDB 1-2-room



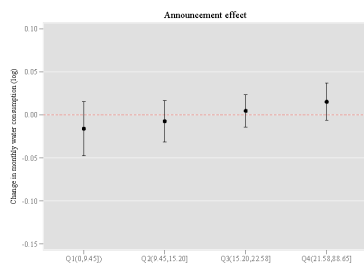
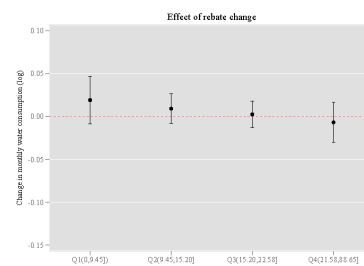
(b) HDB 3-room



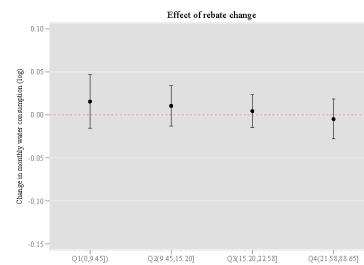
(c) HDB 4-room



(d) HDB 5-room

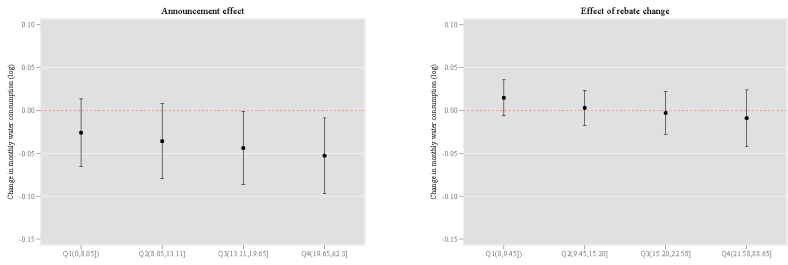


(e) HDB Executive

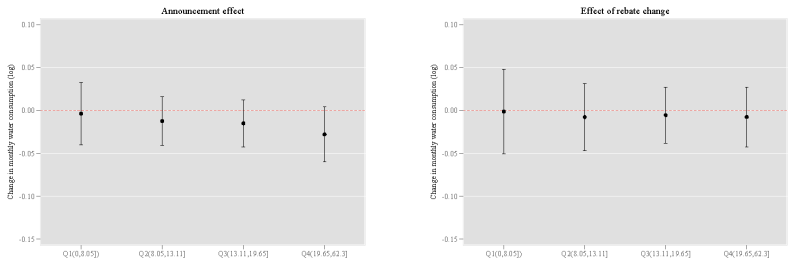


Note: The figures show the effects of announcement and 2012 subsidy increase by water consumption quartile for each HDB flat type. The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6) using 37,368,269 observations from January 2011 to December 2013.

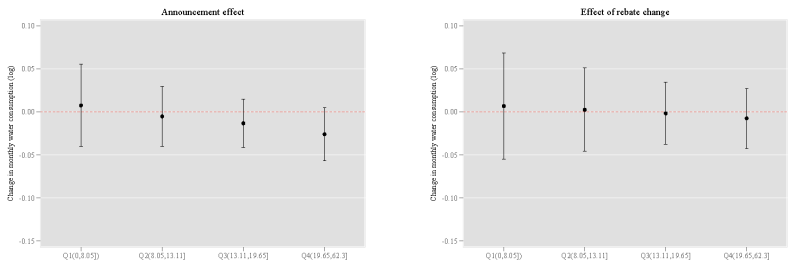
Supplementary Figure 7: Heterogeneous responses to 2019 subsidy by water consumption quartile for each flat type



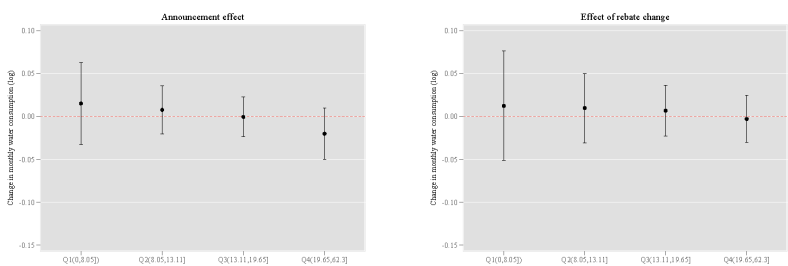
(a) HDB 1-2-room



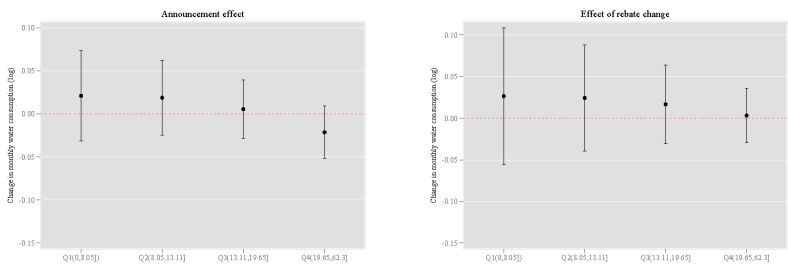
(b) HDB 3-room



(c) HDB 4-room



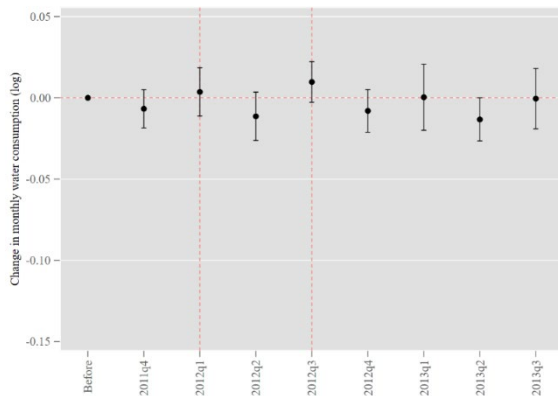
(d) HDB 5-room



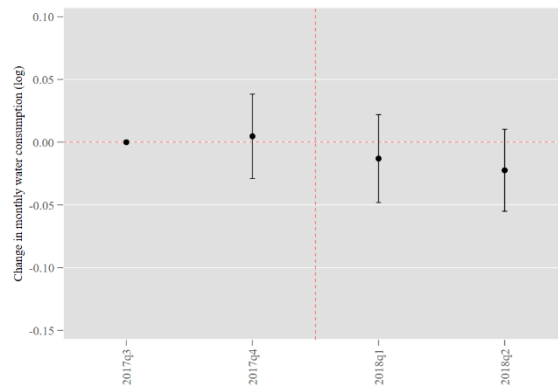
(e) HDB Executive

Note: The figures show the effects of announcement and 2019 subsidy increase by water consumption quartile for each HDB flat type. The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6) using 35,940,387 observations from August 2018 to December 2020.

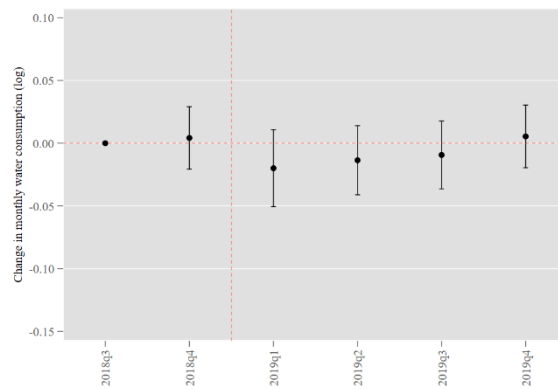
Supplementary Figure 9: Evolutionary effect of subsidy increases



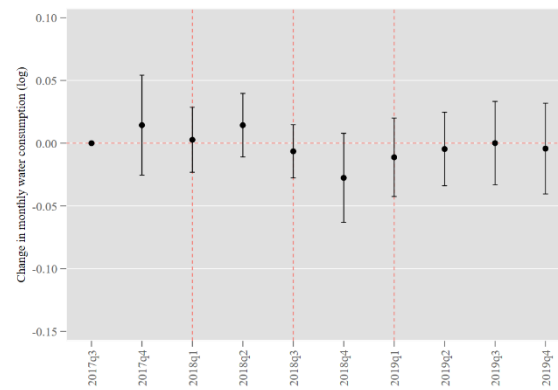
(a) 2012 subsidy increase



(b) 2019 subsidy increase: announcement



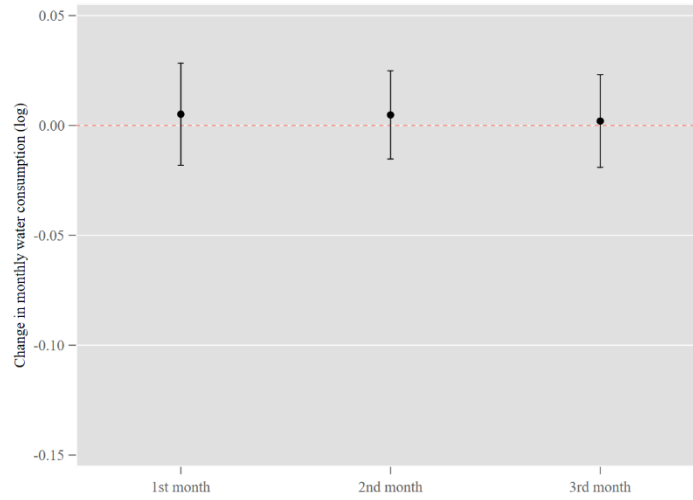
(c) 2019 subsidy increase: implementation



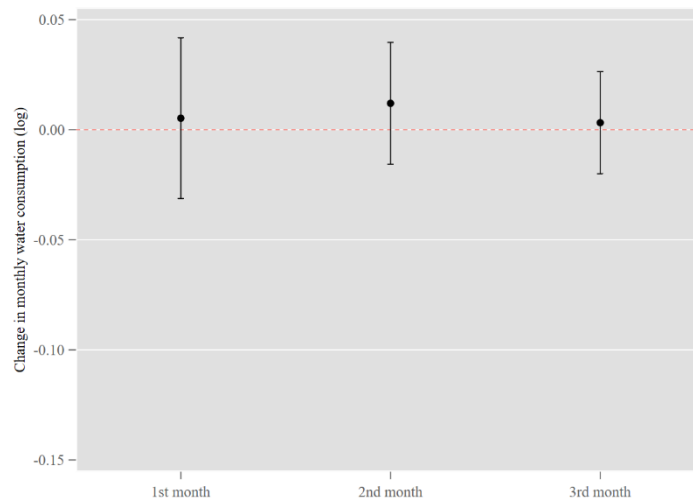
(d) 2019 subsidy increase

Note: The figure shows the coefficients (dots) and corresponding 95% confidence intervals (error bars) for the difference in water consumption between the control and treatment group before and after the subsidy increase in 2012 (subfigure (a)) and 2019 (subfigure (b)-(d)), by estimating equation (5). The sample for estimating the effect of 2012 subsidy increase contains 37,368,269 observations from January 2011 to December 2013 while the sample for estimating the effect of 2019 subsidy increase contains 35,940,387 observations from August 2018 to December 2020. Standard errors are two-way clustered by block and year-month. The vertical lines indicate the timing for the announcement and implementations of the 2012 subsidy increase (from left to right) in subfigure (a); the timing of announcement of 2019 subsidy increase in subfigure (b); the timing of implementation of 2019 subsidy increase in subfigure (c); and the timing of announcement of subsidy increase, second price increase, and the implementation of the 2019 subsidy increase (from left to right) in subfigure (d).

Supplementary Figure 8: Effect of subsidy by distance in time to disbursement



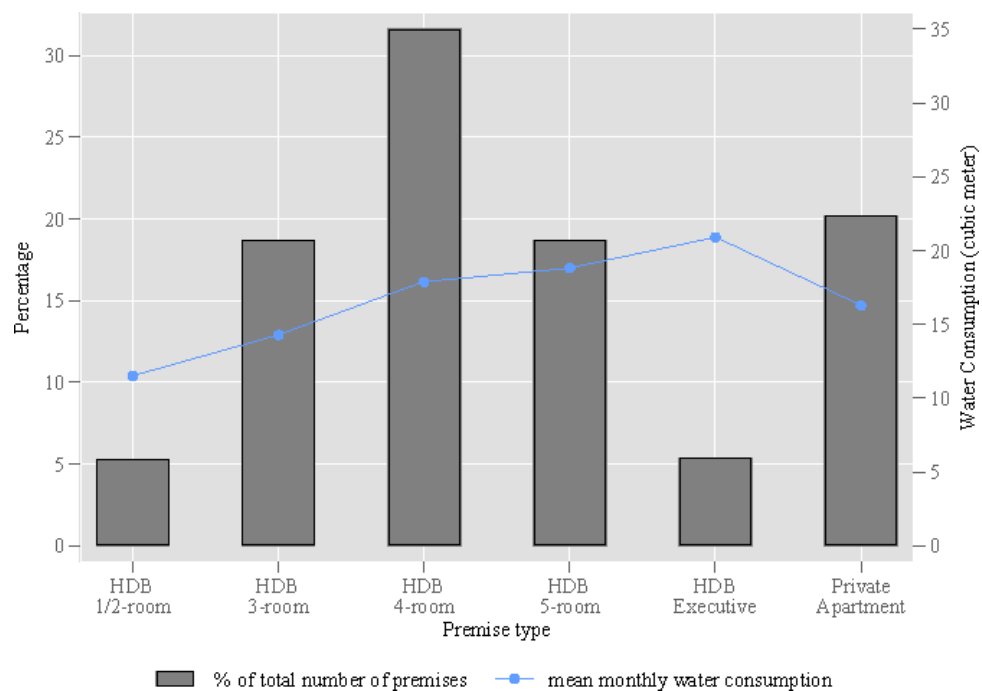
(a) 2012 subsidy increase



(b) 2019 subsidy increase

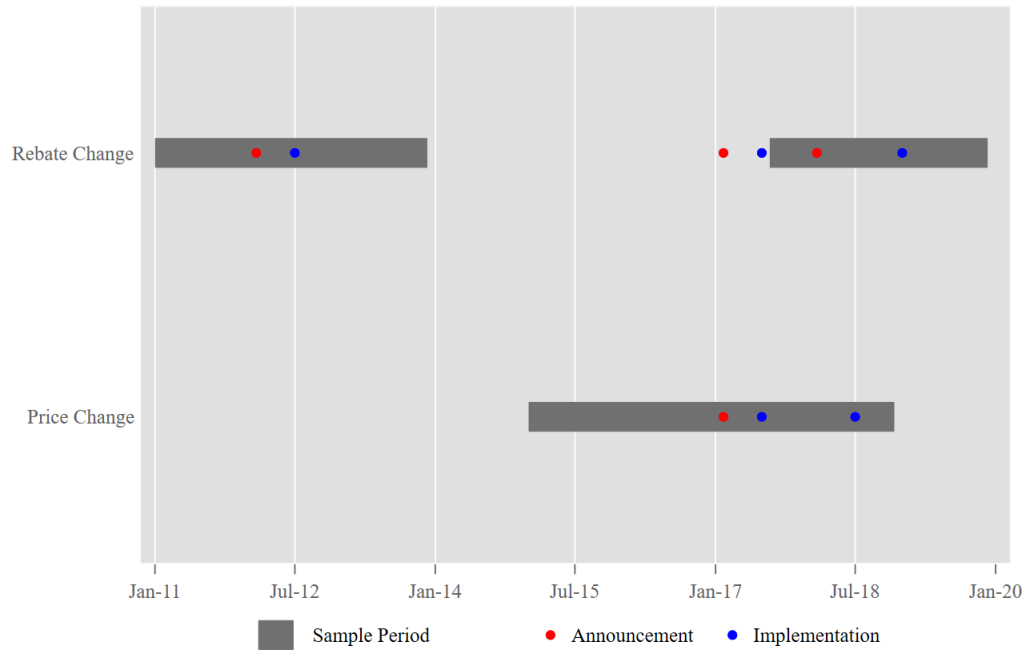
Note: The figures show the effects of subsidy increase by the distance in month to disbursement. The coefficients (dots) and corresponding 95% confidence intervals (error bars) are estimated using equation (6). The sample for estimating the effect of 2012 subsidy increase contains 37,368,269 observations from January 2011 to December 2013 while the sample for estimating the effect of 2019 subsidy increase contains 35,940,387 observations from August 2018 to December 2020.

Supplementary Figure 9: Distribution of premises and mean monthly water consumption



Note: The figure shows the distribution of flat types and their corresponding mean monthly water consumption

Supplementary Figure 10: Sample period



Note: The figure shows the timeline for the announcement (red dots) and implementation (blue dots) of the price increase and 2012 and 2019 rebate increase. The horizontal bars indicate the baseline sample periods used to evaluate each of the policy changes.

Supplementary Table 1: Potable water prices per cubic meter for domestic users

	Before July 1, 2017		From July 1, 2017		From July 1, 2018	
	0-40 m^3	>40 m^3	0-40 m^3	>40 m^3	0-40 m^3	>40 m^3
Tariff	S\$1.17	S\$1.40	S\$1.19	S\$1.46	S\$1.21	S\$1.52
Water Conservation Tax	S\$0.35	S\$0.63	S\$0.42	S\$0.73	S\$0.61	S\$0.99
Waterborne Fee	S\$0.28	S\$0.28	S\$0.78	S\$1.02	S\$0.92	S\$1.18
Sanitary Appliance Fee	S\$2.80 per fitting		Combined into Waterborne Fee			
Water Price	S\$2.10	S\$2.61	S\$2.39	S\$3.21	S\$2.74	S\$3.69
% increase (step-wise)			13.8%	23.0%	14.6%	15.0%
% increase (total)					30.5%	41.4%

Note: The table shows the water price structure in Singapore over time, available at: <https://www.pub.gov.sg/watersupply/waterprice> (accessed on March 10, 2020).

Supplementary Table 2: Household income and monthly water bill

	(1)	(2)	(3)
Type	Monthly income	Monthly water bill	Water bill as % of income
1-2-room	S\$2,521	S\$25	0.99
3-room	S\$5,868	S\$30	0.53
4-room	S\$8,827	S\$38	0.43
5-room	S\$11,244	S\$40	0.36
Executive		S\$44	0.39
Private apartments	S\$21,830	S\$33	0.15

Note: The table compares the average monthly household income and water bill across different flat types. Average monthly household income data is from the Report on Household Expenditure Survey 2017/18 by the Department of Statistics, available at: <https://www.singstat.gov.sg/-/media/files/publications/households/hes201718.png> (accessed on March 10, 2020). Average monthly water bill provided by HDB flat type provided by PUB at <https://www.pub.gov.sg/watersupply/waterprice> (accessed on March 10,2020).

Supplementary Table 3: Regression discontinuity in time

Dependent variable:	(1)	(2)	(3)	(4)
Log of water consumption	Private apartments		HDB flats	
Announcement	-0.014	-0.010	-0.047***	-0.031***
<i>Standard error</i>	(0.009)	(0.008)	(0.005)	(0.008)
<i>t-statistics</i>	-1.54	-1.26	-9.35	-3.77
<i>P-value</i>	0.130	0.215	<0.001	<0.001
<i>95% CI</i>	[-0.031, 0.004]	[-0.025, 0.006]	[-0.057, -0.047]	[-0.047, -0.014]
First price increase		-0.007		-0.052***
<i>Standard error</i>		(0.010)		(0.005)
<i>t-statistics</i>		-0.71		-10.05
<i>P-value</i>		0.482		<0.001
<i>95% CI</i>		[-0.026, 0.013]		[-0.063, -0.042]
Second price increase		0.024		-0.051***
<i>Standard error</i>		(0.014)		(0.006)
<i>t-statistics</i>		1.67		-9.13
<i>P-value</i>		0.101		<0.001
<i>95% CI</i>		[-0.005, 0.052]		[-0.063, -0.040]
First-degree polynomial	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Premise FE	Yes	Yes	Yes	Yes
N	12,021,085	12,021,085	44,932,072	44,932,072
R ²	0.730	0.731	0.786	0.786

Note: This table presents the change in water consumption before and after the price change for private apartments and HDB flats. The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is January 2015 to December 2018. Columns (1) and (3) show the average effect of price by estimating equation (1). Columns (2) and (4) show the decomposed effects by estimating equation (2). *Announcement*, *First price increase*, and *Second price increase* are indicator variables equal 1 for the corresponding time windows of March to July 2017, August 2017 to July 2018, and August 2018 to December 2018, respectively. All models include first-degree polynomial of the running variable (time), account fixed effects and month fixed effects. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 4: Regression discontinuity in time: robustness checks

Dependent variable:	(1)	(2)	(3)	(4)
Log of water consumption	Alternative specification		Alternative sample	Alternative bandwidth
Panel A: Private				
Announcement	0.004	-0.009	0.006	0.003
<i>Standard error</i>	(0.017)	(0.009)	(0.008)	(0.007)
<i>t-statistics</i>	0.21	-1.05	0.75	0.40
<i>P-value</i>	0.836	0.298	0.459	0.693
<i>95% CI</i>	[-0.032,0.039]	[-0.026,0.008]	[-0.010,0.021]	[-0.011,0.016]
First price increase	-0.000	-0.006	0.002	0.003
<i>Standard error</i>	(0.018)	(0.011)	(0.009)	(0.006)
<i>t-statistics</i>	-0.03	-0.56	0.18	0.53
<i>P-value</i>	0.9788	0.578	0.857	0.598
<i>95% CI</i>	[-0.036,0.035]	[-0.028,0.016]	[-0.017,0.020]	[-0.008,0.015]
Second price increase	0.031	0.025	0.000	0.002
<i>Standard error</i>	(0.023)	(0.015)	(0.012)	(0.010)
<i>t-statistics</i>	1.35	1.67	0.03	0.22
<i>P-value</i>	0.183	0.101	0.976	0.825
<i>95% CI</i>	[-0.015,0.078]	[-0.001,0.001]	[-0.024,0.025]	[-0.017,0.022]
N	12,021,085	11,869,620	10,687,059	5,482,368
R ²	0.730	0.731	0.799	0.799
Panel B: HDB				
Announcement	-0.030***	-0.028***	-0.025***	-0.028***
<i>Standard error</i>	(0.014)	(0.009)	(0.008)	(0.007)
<i>t-statistics</i>	-2.06	-3.19	-2.97	-3.84
<i>P-value</i>	0.045	0.003	0.005	<0.001
<i>95% CI</i>	[-0.058,-0.001]	[-0.046,-0.010]	[-0.041,-0.008]	[-0.042,-0.013]
First price increase	-0.053***	-0.050***	-0.050***	-0.048***
<i>Standard error</i>	(0.008)	(0.006)	(0.005)	(0.003)
<i>t-statistics</i>	-6.46	-8.61	-9.87	-15.17
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001
<i>95% CI</i>	[-0.069,-0.036]	[-0.062,-0.038]	[-0.060,-0.040]	[-0.054,-0.042]
Second price increase	-0.047***	-0.048***	-0.065***	-0.064***
<i>Standard error</i>	(0.010)	(0.006)	(0.004)	(0.003)
<i>t-statistics</i>	-4.72	-8.13	-14.71	-20.81
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001
<i>95% CI</i>	[-0.067,-0.027]	[-0.060,-0.036]	[-0.074,-0.056]	[-0.070,-0.057]
N	44,932,072	44,522,850	43,433,638	22,026,661
R ²	0.785	0.786	0.790	0.830
First-degree polynomial	Yes	Yes	Yes	Yes
Month FE	No	Yes	Yes	Yes
Premise FE	Yes	Yes	Yes	Yes
Weather control	No	Yes	No	No

Note: This table presents robustness checks on the change in water consumption before and after the price change for private apartments (Panel A) and HDB flats (Panel B). The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is January 2015 to December 2018. *Announcement*, *First price increase*, and *Second price increase* are indicator variables equal 1 the corresponding time windows of March to July 2017, August 2017 to July 2018, August 2018 to December 2018, and January 2019 onwards, respectively. Columns (1) to (2) show the estimates using alternative specification by exclusion month fix effects and including weather controls. Column (3) shows the estimates using a balanced sample including only accounts with at least two observations before the price increase was announced. Column (4) uses alternative

bandwidth, i.e., bi-monthly instead of monthly water consumption. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 5: Regression discontinuity in time: by HDB flat type

Dependent variable:	(1)	(2)	(3)	(4)	(5)
Log of water consumption	1-/2-Room	3-Room	4-Room	5-Room	Executive
Announcement	-0.034***	-0.038***	-0.028***	-0.025***	-0.034***
<i>Standard error</i>	(0.007)	(0.007)	(0.008)	(0.008)	(0.010)
<i>t-statistics</i>	-5.30	-5.25	-3.29	-2.91	-3.38
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001	<0.001
<i>95% CI</i>	[-0.047, -0.021]	[-0.053, -0.024]	[-0.046, -0.011]	[-0.043, -0.008]	[-0.054, -0.014]
First price increase	-0.061***	-0.064***	-0.048***	-0.044***	-0.060***
<i>Standard error</i>	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
<i>t-statistics</i>	-12.35	-12.40	-9.02	-7.94	-9.58
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001	<0.001
<i>95% CI</i>	[-0.070, -0.051]	[-0.075, -0.054]	[-0.059, -0.038]	[-0.055, -0.033]	[-0.072, -0.047]
Second price increase	-0.069***	-0.066***	-0.045***	-0.038***	-0.067***
<i>Standard error</i>	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
<i>t-statistics</i>	-11.47	-10.45	-7.71	-6.49	-11.63
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001	<0.001
<i>95% CI</i>	[-0.081, -0.057]	[-0.078, -0.053]	[-0.057, -0.033]	[-0.050, -0.026]	[-0.079, -0.056]
N	3,148,398	10,368,286	17,942,593	10,503,389	2,969,406
R ²	0.786	0.782	0.768	0.758	0.766
First-degree polynomial	Yes	Yes	Yes	Yes	Yes
Month FE	No	Yes	Yes	Yes	Yes
Premise FE	Yes	Yes	Yes	Yes	Yes

Note: This table presents robustness checks on the change in water consumption before and after the price change by HDB by flat type. The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is January 2015 to December 2018. *Announcement*, *First price increase*, and *Second price increase* are indicator variables equal 1 the corresponding time windows of March to July 2017, August 2017 to July 2018, August 2018 to December 2018, and January 2019 onwards, respectively. All models include first-degree polynomial of the running variable (time), account fixed effects and month fixed effects. Standard errors in parentheses are two-way clustered by block and year-month. * p < 0.1, ** p < 0.05, *** p < 0.01.

Supplementary Table 6: Robustness checks on the effect of price increase

Dependent variable: Log of water consumption	(1)	(2)	(3)	(4)
Panel A: Alternative Specification				
Post announcement*HDB	-0.039***	-0.038***	-0.039***	-0.033***
<i>Standard error</i>	(0.008)	(0.008)	(0.008)	(0.009)
<i>t-statistics</i>	-5.04	-4.84	-4.98	-3.59
<i>P-value</i>	<0.001	<0.001	<0.001	0.001
<i>95% CI</i>	[-0.054,-0.023]	[-0.054,-0.023]	[-0.055,-0.023]	[-0.052,-0.015]
Post first price change*HDB	-0.021***	-0.022***	-0.019**	-0.033***
<i>Standard error</i>	(0.008)	(0.008)	(0.008)	(0.010)
<i>t-statistics</i>	-2.74	-2.85	-2.56	-3.43
<i>P-value</i>	0.009	0.007	0.014	0.001
<i>95% CI</i>	[-0.037,-0.006]	[-0.038,-0.006]	[-0.035,-0.004]	[-0.053,-0.013]
Post second price change*HDB	-0.028***	-0.029***	-0.021***	-0.009*
<i>Standard error</i>	(0.007)	(0.007)	(0.007)	(0.005)
<i>t-statistics</i>	-4.21	-4.30	-3.18	-1.72
<i>P-value</i>	<0.001	<0.001	0.003	0.091
<i>95% CI</i>	[-0.041,-0.015]	[-0.042,-0.015]	[-0.035,-0.008]	[-0.020,0.015]
Group time trend	No	Yes	Yes	Yes
Account FE	Yes	Yes	No	Yes
Year-month FE	Yes	Yes	Yes	No
Weather controls	No	Yes	No	No
Block FE	No	No	Yes	No
Year FE	No	No	No	Yes
Month FE	No	No	No	Yes
N	56,953,157	56,392,470	56,969,644	56,953,157
R ²	0.773	0.773	0.142	0.772
Panel B: Alternative Sample				
Post announcement*HDB	-0.034***	-0.034***	-0.034***	-0.031***
<i>Standard error</i>	(0.008)	(0.008)	(0.008)	(0.008)
<i>t-statistics</i>	-4.13	-4.19	-4.31	-3.75
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001
<i>95% CI</i>	[-0.050,-0.017]	[-0.051,-0.018]	[-0.050,-0.018]	[-0.047,-0.015]
Post first price change*HDB	-0.022**	-0.021***	-0.018**	-0.018**
<i>Standard error</i>	(0.008)	(0.008)	(0.008)	(0.008)
<i>t-statistics</i>	-2.62	-2.71	-2.30	-2.26
<i>P-value</i>	0.012	0.008	0.025	0.026
<i>95% CI</i>	[-0.039,-0.005]	[-0.036,-0.006]	[-0.034,-0.023]	[-0.033,-0.022]
Post second price change*HDB	-0.027***	-0.028***	-0.027***	-0.027***
<i>Standard error</i>	(0.008)	(0.007)	(0.006)	(0.006)
<i>t-statistics</i>	-3.58	-4.23	-4.77	-4.77
<i>P-value</i>	0.001	<0.001	<0.001	<0.001

	95% CI	[-0.042,-0.012]	[-0.041,-0.015]	[-0.038,-0.016]	[-0.038,-0.016]
Group time trend	Yes	Yes	Yes	Yes	Yes
Account FE	Yes	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes	Yes
N	57,809,131	108,517,299	72,077,527	123,641,600	
R ²	0.756	0.737	0.762	0.731	

Panel C: Alternative dependent variable

	Winsorized	
	1% and 99%	5% and 95%
Post announcement*HDB	-0.039***	-0.035***
<i>Standard error</i>	(0.007)	(0.007)
<i>t-statistics</i>	-5.26	-4.67
<i>P-value</i>	<0.001	<0.001
95% CI	[-0.053, -0.024]	[-0.050, -0.020]
Post first price change*HDB	-0.019***	-0.020***
<i>Standard error</i>	(0.007)	(0.007)
<i>t-statistics</i>	-2.67	-2.70
<i>P-value</i>	0.010	0.010
95% CI	[-0.032,-0.005]	[-0.035,-0.005]
Post second price change*HDB	-0.025***	-0.028***
<i>Standard error</i>	(0.006)	(0.007)
<i>t-statistics</i>	-4.04	-4.05
<i>P-value</i>	<0.001	<0.001
95% CI	[-0.036,-0.012]	[-0.041,-0.014]
Group time trend	Yes	Yes
Account FE	Yes	Yes
Year-month FE	Yes	Yes
N	58,097,069	58,097,069
R ²	0.732	0.780

Panel D: Alternative Clustering

	Two-way		One-way	
	Block and year-month	Account and year-month	Block	Account
Post announcement*HDB	-0.037***	-0.037***	-0.037***	-0.037***
<i>Standard error</i>	(0.008)	(0.008)	(0.002)	(0.001)
<i>t-statistics</i>	-4.65	-4.69	-23.08	-44.28
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001
95% CI	[-0.054, -0.021]	[-0.054, -0.021]	[-0.041,-0.034]	[-0.039,-0.036]
Post first price change*HDB	-0.021***	-0.021***	-0.021***	-0.021***
<i>Standard error</i>	(0.008)	(0.008)	(0.001)	(0.001)
<i>t-statistics</i>	-2.73	-2.73	-21.57	-36.26
<i>P-value</i>	0.009	0.009	<0.001	<0.001
95% CI	[-0.037, -0.006]	[-0.037, -0.006]	[-0.023,-0.019]	[-0.022,-0.020]
Post second price change*HDB	-0.028***	-0.028***	-0.028***	-0.028***
<i>Standard error</i>	(0.007)	(0.007)	(0.001)	(0.001)
<i>t-statistics</i>	-4.20	-4.20	-24.89	-48.13
<i>P-value</i>	<0.001	<0.001	<0.001	<0.001

	95% CI [-0.042, -0.015]	[-0.042, -0.015]	[-0.030,-0.026]	[-0.029,-0.027]
Group time trend	Yes	Yes	Yes	Yes
Account FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
N	56,953,157	56,953,157	56,953,157	56,953,157
R ²	0.773	0.773	0.773	0.773
Panel E: Placebo test with randomly assigned treatment timing				
	Feb 2013	Nov 2013	July 2014	Apr 2015
Post treatment*HDB	-0.006	-0.003	0.001	0.005
<i>Standard error</i>	(0.006)	(0.008)	(0.008)	(0.006)
<i>t-statistics</i>	-0.88	-0.43	0.16	0.77
<i>P-value</i>	0.380	0.670	0.870	0.445
<i>95% CI</i>	[-0.018,0.007]	[-0.019,0.012]	[-0.014,0.017]	[-0.007,0.016]
Group time trend	Yes	Yes	Yes	Yes
Account FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
N	80,570,490	80,570,490	80,570,490	80,570,490
R ²	0.735	0.735	0.735	0.735

Note: This table presents the results of robust checks on the effect of price change on the water consumption for the HDB flats, relative to private apartments by estimating equation (4). The dependent variable is the natural logarithm of 1 plus the monthly water consumption. *HDB* is an indicator variable that takes the value of 1 for HDB flats or treatment group. *Post announcement*, *Post first price increase*, and *Post second price increase* are indicator variables equal 1 for time periods after the corresponding event. Panel A shows the estimates using alternative model specifications, such as excluding group specific time trend, including weather controls, replacing account fixed effects with block fixed effects, and replacing year-month fixed effects with year and month fixed effects. Panel B shows the estimates using alternative samples. Column (1) inclusive of the top and bottom 1% observations in monthly water consumption. Column (2) extends the base sample period to start from January 2011, column (3) extends it to end in December 2019 while column (4) includes the full sample from 2011 to 2019. Panel C shows the estimates using winsorized dependent variables. Panel D shows the estimates using alternative level of standard error clustering, including two-way clustering by block and year-month, two-way clusters by account and year-month, one-way clustering by block, and one-way clustering by account. Panel E shows the estimates from placebo tests by randomly assigning a treatment timing to the pre-treatment sample (2011-2016). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 7: Regression discontinuity in time for industry users

Dependent variable:	(1)	(2)
Log of water consumption	Short-term accommodation	Industries with low water dependency
Announcement	-0.018	-0.003
<i>Standard error</i>	(0.025)	(0.009)
<i>t-statistics</i>	-0.71	-0.28
<i>P-value</i>	0.478	0.779
<i>95% CI</i>	[-0.068, 0.032]	[-0.021, 0.015]
First price increase	0.002	-0.006
<i>Standard error</i>	(0.035)	(0.010)
<i>t-statistics</i>	0.06	-0.65
<i>P-value</i>	0.954	0.522
<i>95% CI</i>	[-0.068, 0.072]	[-0.026, 0.013]
Second price increase	0.004	-0.012
<i>Standard error</i>	(0.050)	(0.015)
<i>t-statistics</i>	0.80	-0.83
<i>P-value</i>	0.428	0.414
<i>95% CI</i>	[-0.061, 0.014]	[-0.042, 0.018]
First-degree polynomial	Yes	Yes
Month FE	Yes	Yes
Account FE	Yes	Yes
N	9,134	1,135,920
R ²	0.958	0.935

Note: This table presents the change in water consumption before and after the price change for industry users including short-term accommodation industry and industries with low water consumption dependency by estimating equation (2). The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is January 2015 to December 2018. *Announcement*, *First price increase*, and *Second price increase* are indicator variables equal 1 for the corresponding time windows of March to July 2017, August 2017 to July 2018, and August 2018 to December 2018, respectively. All models include first-degree polynomial of the running variable (time), account fixed effects and month fixed effects. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 8: Difference-in-differences estimates using industry groups as control

Dependent variable:	(1)	(2)	(3)	(4)
Log of water consumption	Short-term accommodation HDB	Private	Low water dependence industry HDB	Private
Pre*Residential	0.022	0.022	-0.003	0.002
<i>Standard error</i>	(0.016)	(0.025)	(0.002)	(0.026)
<i>t-statistics</i>	1.15	0.88	-1.13	0.08
<i>P-value</i>	0.249	0.382	0.257	0.935
<i>95% CI</i>	[-0.015, 0.058]	[-0.027, 0.071]	[-0.007, 0.002]	[-0.051, 0.055]
Post announcement* Residential	-0.030**	0.005	-0.024***	0.008
<i>Standard error</i>	(0.013)	(0.017)	(0.004)	(0.018)
<i>t-statistics</i>	-2.42	0.31	-6.64	0.41
<i>P-value</i>	0.015	0.754	<0.001	0.687
<i>95% CI</i>	[-0.055, 0.006]	[-0.027, 0.038]	[-0.031, -0.017]	[-0.051, 0.055]
Post first price increase* Residential	-0.029**	-0.007	-0.049***	-0.011
<i>Standard error</i>	(0.014)	(0.018)	(0.002)	(0.018)
<i>t-statistics</i>	-2.10	-0.39	-20.61	-0.65
<i>P-value</i>	0.036	0.698	<0.001	0.523
<i>95% CI</i>	[-0.055, 0.002]	[-0.043, 0.028]	[-0.054, -0.044]	[-0.048, 0.025]
Post second price increase* residential	-0.052***	-0.022	-0.027***	0.017
<i>Standard error</i>	(0.014)	(0.018)	(0.02)	(0.017)
<i>t-statistics</i>	-3.81	-1.23	-10.89	1.01
<i>P-value</i>	<0.001	0.218	<0.001	0.318
<i>95% CI</i>	[-0.078, 0.025]	[-0.058, 0.013]	[-0.032, -0.022]	[-0.017, 0.052]
Group specific time trend	Yes	Yes	Yes	Yes
Group-month FE	Yes	Yes	Yes	Yes
Account FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
N	44,794,097	11,892,285	45,887,123	13,145,199
R ²	0.791	0.742	0.836	0.813

Note: This table presents the effect of water price increase on the water consumption for the HDB flats and private apartments, relative to short-term accommodation industry and industries with low water consumption dependency, respectively. The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is January 2015 to December 2018. The industry groups are identified by the Singapore Standard Industry Code (SSIC). An industry is considered to have very low water consumption dependency if it receives a 0 out of a 0-3 scale on “Direct water use: High volume withdrawal/ consumption dependence” in the Water Watch – CDP Water Impact Index. We restrict the sample to be balanced to eliminate the effect of firm entry and exist on water efficiency and consumption patterns; accounts that experience sharp changes in water consumption of more than 500% percent (or top 1% of the changes), which is likely driven by extreme circumstances such as sudden increase in demand, renovation, upgrading in technology, etc., are excluded. *Residential* is an indicator variable that takes the value of 1 for the treatment group of HDB flats or private apartments. *Pre* is an indicator variable taking the value of 1 for the six months before the announcement of price and subsidy change. *Post announcement*, *Post first price increase*, *Post second price increase* and *Post subsidy*

increase are indicator variables equal 1 for time periods after the corresponding event. All models include group-specific time trend, group-month fixed effects, account fixed effects and year-month fixed effects. Standard errors in parentheses are two-way clustered by account and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 9: Quarterly utility subsidy

Type	Before 2012/6	2012/7-2017/6	2017/7-2018/12	After 2019/1
1/2-room	S\$45	S\$65	S\$95	S\$100
3-room	S\$25	S\$60	S\$85	S\$90
4-room	S\$22.50	S\$55	S\$75	S\$80
5-room	S\$15	S\$50	S\$65	S\$70
Executive	S\$10	S\$45	S\$55	S\$60

Note: The table shows the amount of quarterly utility rebates over time across different flat types. The data is from the annual press release by the Ministry of Finance, available at: <https://www.mof.gov.sg/newsroom/press-releases> (accessed on March 10,2020).

Supplementary Table 10: Robustness checks on the effect of 2012 subsidy increase

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
Log of water consumption		Alternative specification			Alternative sample	
Post announcement*HDB	-0.006	0.006	0.002	-0.015*	-0.010	-0.002
<i>Standard error</i>	(0.008)	(0.012)	(0.013)	(0.009)	(0.008)	(0.008)
<i>t-statistics</i>	-0.72	0.51	0.18	-1.72	-1.31	-0.28
<i>P-value</i>	0.474	0.614	0.855	0.095	0.205	0.783
<i>95% CI</i>	[-0.022, 0.010]	[-0.019, 0.031]	[-0.024, 0.029]	[-0.033, 0.027]	[-0.027, 0.006]	[-0.018, 0.013]
Post subsidy increase*HDB	-0.004	0.006	0.002	-0.003	-0.005	-0.000
<i>Standard error</i>	(0.007)	(0.009)	(0.010)	(0.005)	(0.007)	(0.006)
<i>t-statistics</i>	-0.57	0.69	0.25	-0.65	-0.76	-0.05
<i>P-value</i>	0.570	0.494	0.806	0.520	0.456	0.957
<i>95% CI</i>	[-0.017, 0.009]	[-0.013, 0.026]	[-0.018, 0.023]	[-0.012, 0.063]	[-0.019, 0.090]	[-0.013, 0.012]
Group time trend	No	Yes	Yes	Yes	Yes	Yes
Account FE	Yes	Yes	No	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	No	Yes	Yes
Weather controls	No	Yes	No	No	No	No
Block FE	No	No	Yes	No	No	No
Year FE	No	No	No	Yes	No	No
Month FE	No	No	No	Yes	No	No
N	38,381,985	38,381,983	38,394,208	38,381,985	25,420,629	81,720,645
R ²	0.784	0.784	0.132	0.784	0.802	0.748

Note: This presents robust checks on the effect of 2012 rebate change on the water consumption for the HDB flats, relative to private apartments by estimating equation (4). The dependent variable is the natural logarithm of 1 plus the monthly water consumption. *HDB* is an indicator variable that takes the value of 1 for HDB flats or treatment group. *Post announcement* and *Post subsidy increase* are indicator variables equal 1 for time periods after the corresponding event. Columns (1) to (4) show the estimates using alternative model specifications, such as excluding group specific time trend, including weather controls, replacing account fixed effects with block fixed effects, and replacing year-month fixed effects with year and month fixed effects. Sample period is January 2011 to December 2013 for columns (1) to (4). Column (5) restricts the sample period to December 2012 while column (6) extends it to December 2016. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 11: Effect of 2019 subsidy increase

Dependent variable:	(1)	(2)	(3)
	Log of water consumption		
Post announcement*HDB	-0.020		-0.019
<i>Standard error</i>	(0.020)		(0.014)
<i>t-statistics</i>	-1.02		-1.30
<i>P-value</i>	0.330		0.206
<i>95% CI</i>	[-0.064, 0.023]		[-0.049, 0.011]
Post second price increase*HDB			-0.021**
<i>Standard error</i>			(0.008)
<i>t-statistics</i>			-2.57
<i>P-value</i>			0.017
<i>95% CI</i>			[-0.039, -0.004]
Post subsidy increase*HDB		-0.009	0.001
<i>Standard error</i>		(0.017)	(0.015)
<i>t-statistics</i>		-0.85	0.05
<i>P-value</i>		0.413	0.964
<i>95% CI</i>		[-0.033, 0.015]	[-0.030, 0.032]
Group time trend	Yes	Yes	Yes
Account FE	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
N	14,578,483	21,342,188	35,940,387
R ²	0.837	0.826	0.801

Note: This table presents the effect of subsidy increase on the water consumption for the HDB flats, relative to private apartments. The dependent variable is the natural logarithm of 1 plus the monthly water consumption. Sample period is August 2017 to July 2018, Aug 2018 to December 2019 and August 2017 to December 2019 for columns (1) to (3) respectively. Columns (1) and (2) estimate the effect of 2019 announcement and subsidy increase separately; while column (3) jointly estimates the announcement of 2019 subsidy change, the second price increase, and the subsidy increase. *HDB* is an indicator variable that takes the value of 1 for HDB flats or treatment group. *Post announcement*, *Post second price increase* and *Post subsidy increase* are indicator variables equal 1 for time periods after the corresponding event. All models include group-specific time trend, account fixed effects and year-month fixed effects. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Supplementary Table 12: Effect of 2019 subsidy increase: robustness checks

Dependent variable: Log of water consumption	(1)	(2)	(3)	(4)
Panel A: announcement effect				
Post announcement*HDB	-0.032***	-0.021	-0.024	-0.020
<i>Standard error</i>	(0.009)	(0.020)	(0.020)	(0.020)
<i>t-statistics</i>	-3.46	-1.08	-1.15	-1.02
<i>P-value</i>	0.05	0.303	0.273	0.330
<i>95% CI</i>	[-0.053, -0.012]	[-0.065, 0.022]	[-0.037, 0.021]	[-0.064, 0.023]
Group time trend	No	Yes	Yes	Yes
Account FE	Yes	Yes	No	Yes
Year-month FE	Yes	Yes	Yes	No
Weather controls	No	Yes	No	No
Block FE	No	No	Yes	No
Year FE	No	No	No	Yes
Month FE	No	No	No	Yes
N	14,578,483	14,559,490	14,597,597	14,578,483
R ²	0.837	0.837	0.144	0.837
Panel B: implementation effect				
Post subsidy increase*HDB	-0.009	-0.010	-0.002	-0.009
<i>Standard error</i>	(0.011)	(0.011)	(0.010)	(0.011)
<i>t-statistics</i>	-0.85	-0.90	-0.19	-0.85
<i>P-value</i>	0.413	0.385	0.849	0.411
<i>95% CI</i>	[-0.033, 0.015]	[-0.033, 0.014]	[-0.025, 0.021]	[-0.033, 0.015]
Group time trend	No	Yes	Yes	Yes
Account FE	Yes	Yes	No	Yes
Year-month FE	Yes	Yes	Yes	No
Weather controls	No	Yes	No	No
Block FE	No	No	Yes	No
Year FE	No	No	No	Yes
Month FE	No	No	No	Yes
N	21,342,188	21,340,658	21,346,281	21,342,188
R ²	0.826	0.826	0.140	0.826

Note: This table presents robust checks on the effect of 2018/19 rebate change on the water consumption for the HDB flats, relative to private apartments by estimating equation (4). The dependent variable is the natural logarithm of 1 plus the monthly water consumption. *HDB* is an indicator variable that takes the value of 1 for HDB flats or treatment group. *Post announcement* and *Post subsidy increase* are indicator variables equal 1 for time periods after the corresponding event. Columns (1) to (4) show the estimates on the effect of announcement (Panel A) and rebate increase (Panel B) respectively, using alternative model specifications, such as excluding group specific time trend, including weather controls, replacing account fixed effects with block fixed effects, and replacing year-month fixed effects with year and month fixed effects. Sample period is August 2017 to July 2018 for Panel A and August 2018 to December 2019 for Panel B. Standard errors in parentheses are two-way clustered by block and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 13: Effect of subsidy increase
on electricity consumption and household expenditure

Dependent Variable:	(1)	(2)	(3)	(4)
	Log of electricity consumption			Log of expenditure
Time of rebate increase:	2012	2017	2019	2017
Post announcement*HDB	-0.013	0.018	0.001	-0.045
<i>Standard error</i>	(0.008)	(0.013)	(0.014)	(0.036)
<i>t-statistics</i>	-1.60	1.34	0.05	-1.25
<i>P-value</i>	0.112	0.182	0.957	0.211
<i>95% CI</i>	[-0.029, 0.003]	[-0.008, 0.044]	[-0.027, 0.028]	[-0.115, 0.025]
Post subsidy increase*HDB	0.005	-0.014	-0.002	0.022
<i>Standard error</i>	(0.009)	(0.012)	(0.015)	(0.041)
<i>t-statistics</i>	0.49	-1.16	-0.17	0.54
<i>P-value</i>	0.623	0.246	0.866	0.592
<i>95% CI</i>	[-0.014, 0.023]	[-0.037, 0.010]	[-0.034, 0.012]	[-0.059, 0.103]
Group trend	Yes	Yes	Yes	Yes
Household FE				Yes
Flat-type FE	Yes	Yes	Yes	
Year-month FE	Yes	Yes	Yes	Yes
N	180	240	145	19,082
R ²	0.999	0.999	0.999	0.524

Note: This table presents the effect of subsidy increases on the electricity consumption and expenses on grocery for the HDB flats, relative to private apartments. The dependent variable is the natural logarithm of 1 plus the monthly electricity consumption by HDB flat types for columns (1) to (3) and natural logarithms of 1 plus the monthly household expenses on grocery for column (4). Sample period is January 2011 to December 2013 for column (1); January 2015 to December 2018 for columns (2); July 2017 to December 2019 for column (3); and January 2016 to December 2017 for column (4). *HDB* is an indicator variable that takes the value of 1 for HDB flats or treatment group. *Post announcement* and *Post subsidy increase* are indicator variables equal 1 for time periods after the corresponding event. All models include group-specific time trend and year-month fixed effects. Models on electricity consumption (columns (1)-(3)) control for flat type fixed effects while model on household expenses (column (4)) controls for household fixed effects. Standard errors in parentheses for columns (1)-(3) are clustered by year-month and for column (4) are two-way clustered by household and year-month. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Table 14: Descriptive statistics

	(1)		(2)		(3)
	Control		Treatment		Normalized
	Mean	SD	Mean	SD	Difference
Mean before price change (m^3)	16.34	12.24	17.32	10.58	-0.08
Mean after price change (m^3)	14.29	10.16	15.44	9.52	-0.116
Observations	24,951,023		98,702,231		

Note: Table provides the mean and standard deviation of monthly water consumption for the control group or private apartments (column (1)), treatment group or HDB flats (column (2)), and the normalized differences in the mean water consumption between the two groups (column (3)).