The Design of Public Housing Programs: Evidence from Hong Kong

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Abstract

When designing public housing programs, governments must choose whether to rent or sell, whether to conduct regular income checks, and whether to allow transfer of sold units. This paper analyzes how the transferability and contingency of occupancy rights granted to public housing participants affect program efficiency and targeting. Specifically, I study Hong Kong's Tenants Purchase Scheme, which converted 120,000 rental units into ownership units with transfer restrictions. Leveraging its staggered roll-out between 1998 and 2006, I show that the scheme reduced household sizes and increased incomes in treated estates, did not reduce misallocation, and likely worsened targeting of low-income households.

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1 Introduction

Many governments operate public housing programs. In designing these programs, governments must decide whether to rent or sell the units, whether to make rental occupancy contingent on regular income checks and household size, and whether to restrict the leasing and resale of sold units. The nature of the property rights granted to public housing residents vary widely across time and space. For example, 31 percent of Hong Kong's population reside in public rental housing, for which continuing occupancy depends on income and household size. Another 16 percent of Hong Kong's population live in subsidized ownership units, where continuing occupancy is not conditional, but a hefty premium must be paid before owners can resell or lease. By contrast, 80 percent of Singapore's population reside in government-built subsidized ownership units that automatically become fully transferable after five years of ownership. Moreover, the Right-to-Buy program in the UK transferred ownership of over 2.8 million council houses to tenants between 1980 and the mid-2000s (Disney and Luo 2017), while Ireland's sale of council houses boosted its home ownership rate from 70.8 percent in 1971 to 79.3 percent in 1991.[1] Despite their variety, the design of property rights over public housing has received little attention from economists, even though such choices may fundamentally alter the effects of public housing provision.[2]

To inform policy design, this paper analyzes the effects of Hong Kong's Tenants Purchase Scheme (TPS), which allowed 183,700 households to convert their public rental housing units into ownership units at heavily discounted prices. The scheme provides a unique opportunity to study how a change in property rights affects the effects of public housing provision, since the supply and initial allocation of public housing was left unchanged. In theory, the conversion of rationed public rental housing into transferable ownership units could substantially reduce housing misallocation and increase wealth (Wang 2011, 2012). In practice, transfer restrictions may prevent households from moving. Therefore, TPS may have merely allowed residents to

[1] Relatedly, social housing tenants in Austriacan acquire a right-to-buy option by paying a capital contribution at the start of their tenancy. In Sweden, the conversion scheme allows tenants in public rental housing to establish a cooperative. See Legislative Council Secretariat (2020).

[2] Recent literature instead focuses on the importance of mechanism design when initially allocating public housing (Thakral 2016, Forthcoming; Waldinger 2021; Lee, Kemp and Reina 2022; Naik and Thakral 2022).

continue to occupy units regardless of their income and household size. This benefits sitting residents, but it also worsens the targeting of subsidized housing to low-income renters.

To identify the effect of TPS on treated housing estates, I leverage the scheme's staggered and incomplete roll-out across housing estates between 1998 and 2006 in a dynamic difference-in-differences design. First, I construct a control group of non-TPS housing estates with similar construction years as TPS estates. I then use the interaction-weighted estimator proposed by Sun and Abraham (2020), which computes the mean of the cohort-specific average treatment effects on the treated estates, weighted by the shares of each treatment cohort. I examine outcomes such as population, household sizes, household incomes, user costs, and commute times using restricted-access data from the Hong Kong Population Census.

My main finding is that TPS caused total population and average household size in treated estates to fall and the average household income to rise. These effects are large. Total population decreased by 5 percent within a few years, and eventually decreased by roughly 7 percent, or roughly 51,000, within two decades. Average household size declined by roughly 5 percent within two decades. Average household income rose by 7 percent within a few years, and was 23 percent higher 15 years later.

These effects are not due to increased housing transferability. Since TPS included a requirement for households to repay a hefty premium before resale, which was functionally similar to a very large transaction levy, households were disincentivized from transfering their ownership to other households. Most purchasing households did not move away for many years, as confirmed by three auxilliary findings. First, as of 2016, nearly 99 percent of households in sold TPS units were owner-occupiers who had not paid the land premium to the government and, as such, were legally prohibited from leasing out or reselling their units on the open market. Second, transfer of units with unpaid premium among a restricted set of eligible buyers was also very limited. Third, TPS did not reduce commuting times, despite prior evidence that misallocation of public housing in Hong Kong has generated spatial mismatch (Lui and Suen 2011).

My estimates are also not explained by the mortgage costs of sitting residents. We observe that TPS reduced the average user cost of households in the treated estates, which is defined as the sum of monthly rental and mortgage payments. Pressure to fulfill mortgage obligations

therefore cannot explain the increase in employment and income.

The findings are instead explained by the fact that purchasing tenants are no longer subject to the household-size-contingent income limits and unit allocation rules. First, public renters with incomes in excess of income limits must pay either 1.5 times rent or double rent. Furthermore, if the number of household members in a rental flat falls below the prevailing standard, the household must move to a smaller flat. Consistent with this explanation, I find that the share of households with incomes above the 1.5 times and double rent income limits dramatically increased, by 80 and 96 percent, respectively, within two decades. There is also considerable evidence that households purchased TPS units in order to avoid these administrative rules.

While the above findings strong suggest that TPS benefited sitting tenants, TPS likely had less positive effects on the broader population due to worsened targeting of public housing to low-income populations. By disincentivizing well-off tenants from moving up the housing ladder, TPS likely reduced the availability of public housing units. Moreover, TPS reduced the population in treated estates and this missing population must be housed elsewhere. Combined, these effects likely caused the low-income population to face both higher rents in the low-end private sector and longer waiting times for public housing.

In summary, the contributions of this paper are to (1) highlight that the nature of the property rights granted to residents matters for the efficacy and targeting of public housing programs, (2) show that the contingency of continuing occupancy on household income and composition can dramatically alter household size, composition, and income, (3) illustrate how non-transferable property rights prevents housing reallocation and welfare gains from public housing privatization. Despite their importance, the growing literature on the design of public housing programs has paid little attention the nature of property rights granted to public housing residents and has instead focused the mechanism for the initial allocation of public housing (Thakral 2016, Forthcoming; Waldinger 2021; Lee, Kemp and Reina 2022; Naik and Thakral 2022).

At the heart of this paper are novel estimates of the long-run effects of converting rental housing into ownership housing. Unlike prior literature on Hong Kong's TPS, this paper leverages its staggered roll-out across estates fro causal identification.[3] A closely related contribution

[3]Ho and Wong (2006) present time-series evidence on the effects of TPS on private-sector housing prices, but

is Wang (2011, 2012), who shows that a similar privatization of state employee housing in China reduced housing misallocation and relaxed credit constraints. Perhaps surprisingly, TPS did not alter housing allocation, despite longstanding evidence of government misallocation (Wong and Liu 1988; Lui and Suen 2011). This finding is explained by the fact that transfer restrictions in the form of premium repayment requirements prevented housing reallocation.

Despite the lack of reallocation, I show that TPS dramatically increased household incomes and reduced household sizes as a result of relaxed income checks and administrative rules. These findings are related to a large literature considers the effects of housing assistance on economic and health outcomes (e.g., Jacob 2004; Kling, Ludwig and Katz 2005; Jacob and Ludwig 2012; Chyn 2018; Dijk 2019). They also relate to a literature that highlights the trade-off between efficiency and redistribution when targeting public assistance to the households that need it most (Akerlof 1978; Nichols and Zeckhauser 1982). Recent empirical papers study this tension in welfare programs and public housing allocation mechanisms (Deshpande and Li 2019; Finkelstein and Notowidigdo 2019; Lieber and Lockwood 2019; Waldinger 2021). My study highlights that the design of property rights over public housing also affects this trade-off.

The paper proceeds as follows. Section 2 provides a theoretical framework. Section 3 describes relevant institutional background. Section 4 provides descriptive evidence. Section 5 presents the estimated effects of TPS. Section 6 discusses the mechanisms underlying the effects. Section 7 discusses welfare implications. Section 8 concludes.

2 Theoretical Framework

Public housing programs around the world can be classified into three types: rental, transferable ownership, and non-transferable ownership. As explained in this section, these three types of public housing differ along two dimensions: (1) the *contingency* of continuing occupancy on participant characteristics such as income and household size, and (2) the *transferability* of occupancy rights to other persons. Contingency and non-transferability reduce the welfare of participants, but they may allow governments to better target subsidized housing to those in

their estimates are likely confounded by contemporaneous events such as the Asian Financial Crisis.

need.[4]

The predominant form of public housing is *rental* housing. In this arrangement, eligible households are granted exclusive occupancy rights to a unit, which are *contingent* on the households continuing to fulfill income and size requirements. These occupancy rights are also *non-transferable*, since the resident households are prohibited from subleasing.

By contrast, *ownership* housing may either be *transferable* or *non-transferable*. In contrast to rental housing, occupancy in ownership units by the purchasing household is not contingent on their continuing characteristics. For transferable ownership units, occupancy rights can be both sold and leased to other parties. Singapore's Housing & Development Board (HDB) housing, for example, are ownership units that automatically become fully transferable after five years. For non-transferable ownership units, neither leasing nor transfers are allowed. As explained below, resale and leasing of Hong Kong's subsidized ownership units require the payment of an unaffordable premium and therefore is effectively prohibited.

According to economic theory, reduced contingency and increased transferability unambiguously increases the welfare of sitting residents. Removing regular income tests, for example, empowers the sitting households to continue to occupy the unit regardless of their income. An increase in the transferability empowers the sitting household to resell, lease, or use the property as collateral to obtain a loan. New actions become available, while the existing actions are still possible, so the household unambiguously benefits.

Making occupancy rights transferable also creates a more liquid market for houses, which may bring multiple additional benefits. It could reduces misallocation of housing resources (Glaeser and Luttmer 2003; Wang 2011). It could provide better incentives for owners to upgrade their properties and invest in neighborhood-level amenities (Disney et al. 2021). It could also allow the owned assets to become collateralized, thereby relaxing credit constraints and increasing entrepreneurial activity (Wang 2012).

However, income-contingency and non-transferability may help to target public housing provision to the needy. These restriction on household choice may improve targeting if house-

[4]Other aspects of public housing administration, such unit allocation, rent and price setting, redevelopment, and property management, are important but beyond the scope of this paper.

holds with better outside options self-select out of public housing and thereby make room for more disadvantaged households. This trade-off between redistribution and efficiency has long been highlighted by economist (Akerlof 1978; Nichols and Zeckhauser 1982) and was recently explored by Arnosti and Shi (2020) and Waldinger (2021) in the context of public housing allocation mechanisms.

As shown below, Hong Kong's TPS rollout represents a switch from a rental to a non-transferable ownership program. TPS granted its participants occupancy rights that were no longer contingent on income testing and household size, but made these rights non-transferable by requiring the payment of a hefty premium before the property can become resold or leased. Economic theory therefore predicts that the TPS rollout should improve the outcomes of sitting tenants, but worsen the targeting of public housing towards households with greatest need.

3 Institutional Background

In this section, I explain in detail how TPS changed the contingency and transferability of occupancy rights granted to eligible public rental housing (PRH) residents.

3.1 Public Rental Housing in Hong Kong

The purpose of Hong Kong's PRH program is to provide subsidised flats for qualifying low-income families. Applicants are funnelled through a waiting-list system, which processes applications mainly on a first-come-first-served basis. Individual flats are then offered to applicants by random computer batching according to each applicant's household size, flat allocation standards, and choice of district. Applicants receive up to three housing offers, which are given out one at a time. If all three offers are rejected, then the applicant must wait one year before reapplying. The average wait time for housed applicants was 2.0 years in 2011, but had risen to 5.5 years by 2019. In 1998, the year before the launch of TPS, 2.3 million Hong Kong residents lived in PRH units, roughly 38 percent of the total population.[5] The average rent of a PRH unit

[5]See Housing Department (2021) and Legislative Council Secretariat (2020). As of March 2019, public rental housing flats accounted for about 29 percent of the stock of permanent housing and housed about 31 percent of

in 2016 is $1,563, which is on average about 18.4 percent of a similar private-sector unit.[6]

Well-off Tenants Policy. To improve the targeting of public housing provision to low-income families, the "Well-off Tenants Policy" was created to reallocate PRH units from households whose incomes have significantly risen to families that are more in need. This policy requires tenants who have lived in PRH flats for 10 years or more to declare the income and assets of all household members biennially. Households who report total monthly incomes in excess of household-size-contingent income limits are then required to pay either 1.5 times rent or double rent, and households who additionally have large net asset holdings are asked to move out. To encourage truthful reporting, income and asset declarations are randomly chosen for in-depth verification. Households with all members aged 60 or above are exempted from the policy.[7]

Under-occupation. To ensure equitable utilization of PRH units, the government reallocates units if the size of a household significantly falls due to move-out, death, marriage, or emigration of some household members. To address under-occupation (UO), tenants are required to declare biennially their occupancy position. These declarations are verified through random flat visits. If the number of household members in a PRH flat is below the minimum number set by the HA for the flat, the household is asked to move to a suitable flat. Under-occupation is a significant problem. As of March 2021, there were 79,380 UO households, roughly 10 percent of the total number of PRH households, of which 5,320 were considered prioritized UO cases. Between 2016 and 2020, the government resolved an average of about 2,200 prioritized UO cases each year.[8]

total households in Hong Kong (Census and Statistics Department 2020; Transport and Bureau 2019).

[6]To ensure fair comparisons between rent of PRH units and a private-sector units, flats with floor area between 7 and 13 square meters is used as a proxy of private units. Weighted by the number of PRH units in each districts, the weighted average rent of a similar private-sector unit is then being computed.

[7]See Audit Commission (2007) for more details. The Housing Subsidy Policy (HSP) and the Policy on Safeguarding Rational Allocation of Public Housing Resources (PSRA) were implemented in 1987 and 1996 respectively and are collectively referred to as "Well-off Tenants Policies". Under the PSRA, household income and net asset value are adopted as the two criteria for determining PRH households' eligibility to continue to receive subsidised public housing. Under section 26(1) of the Housing Ordinance, any person who knowingly makes any false statement are liable on conviction to a maximum fine of $50,000 and to imprisonment for six months. Between 2003 and 2006, roughly 6 percent of households were found to have under-reported their incomes, of which 18 percent were prosecuted.

[8]See Audit Commission (2013) and GovHK (2021).

3.2 History of Tenants Purchase Scheme

In 1998, the Hong Kong Housing Authority launched the Tenants Purchase Scheme (TPS), which allowed PRH tenants to buy the flats they lived in at a discounted price. The stated goal of the policy was to boost Hong Kong's homeownership rate to 70 percent within ten years' time. Between 1998 and 2006, units in 39 PRH estates, totalling 183,700 units and comprising roughly 27 percent of the total stock of PRH units, were made available for sale.

Strong incentives were put in place to encourage rapid sale. Almost all sitting tenants in the selected estates were offered the opportunity to purchase.[9] Tenants who do not wish to purchase can continue to rent and occupy their flats as before. The purchase price was set at replacement cost, but given a further discount of 60% on purchase within the first year, which is as low as 12% of market value.[10] To fund the purchase, the government agreed with a number of banks and financial institutions to provide mortgages of up to 100% of the balance of the purchase price of the flat for up to 25 years. Following the sale, the unit owner became responsible for maintenance and repairs, building management fees, as well as property taxes. By 2006, roughly 104,400 units had been purchased.

However, the government re-positioned housing policies in 2002 in response to the economic downturn and collapse of private-sector property prices following the Asian financial crisis. This included the dropping of the target for home ownership, and the withdrawal of Housing Authority from the property sale market as far as possible. In August 2005, the Housing Authority announced that there will be no further sale of PRH flats after 2006. In Section 5, I leverage the staggered and incomplete roll-out of TPS across housing estates to identify the impact of the program.[11]

[9]The exceptions were those living in the following flats: 1) Housing for Senior Citizens and Small Household Block; 2) Flats used for social welfare purposes; and 3) Flats with common entrance and communal facilities such as bathroom, kitchen and entrance.

[10]New tenants who purchase TPS flats enjoy a full credit if they buy within the first year and a halved credit in the second year. After the second year, no credit will be given. Purchasers will need to pay, apart from the price of the flat, the stamp duty, registration fees and legal costs. See Housing Authority (2014) for more details.

[11]In each of the first five phases of TPS launch, around 26,000 to 28,000 PRH flats in six selected estates were offered for sale. In the last phase, which comprised phase 6A and phase 6B, around 49,000 PRH flats in nine estates were offered for sale (Legislative Council Secretariat 2020).

3.3 Restrictions on Resale and Leasing of TPS Units

The TPS program granted permanent but effectively non-transferable occupancy rights to purchasing households. Specifically, TPS flat owners were no longer subject to the Well-off Tenant Policy and under-occupancy unit allocation rules of PRH tenants, but they were also restricted from resale and letting by the requirement to pay a premium to the government and the illiquidity of the restricted secondary market.

The transfer restrictions were very prohibiting. TPS household cannot lease or resale on the open market until five years after purchase and, more importantly, until a premium equivalent to current value of the original discount is paid to the government.[12] According to property transaction records, extremely few TPS owners paid the premium. For example, in the district of Tuen Mun, there were 14,383 sold TPS unit as of September 23, 2021, of which only 200 had premiums paid between 2005 and 2020. In other words, the number of premium payments per year was less than 0.1 percent of the stock of sold TPS units.[13] To see why, suppose the unit was purchased at 12 percent of the initial market value, and the household now wishes to sell the unit on the open market and simultaneously purchase another unit of equivalent value on the open market. The premium requirement is equivalent to an 88 percent transaction levy. Only households desperate to obtain cash would be willing to pay it.

In addition to selling on the open market after payment of a premium, flats can be sold in a restricted market, namely the Home Ownership Scheme (HOS) Secondary Market, three years after initial purchase to public housing renters and other eligible purchasers without payment of a premium. Transactions on the HOS Secondary Market were also rare. For TPS units in Tuen Mun, there were only 702 between the beginning of 2002 and October 2021. The number

[12] In the first two years after the sale, a TPS flat owner can only sell the flat back to HA at the list price. Within the third to fifth years from the date of first assignment, TPS flat owners can sell back their flats to Housing Authority at assessed market value less the original purchase discount. If HA declines to buy back the flats, however, TPS flat owners can sell, let or assign their flats in the open market. In addition, the Housing Authority may give consent to a request for change of ownership under special circumstances, such as divorce or separation, emigration or long-term working abroad, death, old age, bankruptcy, or terminal illness of owner. TPS owners letting units in breach of the Housing Ordinance are liable on conviction to a maximum fine of $500,000 and to imprisonment for one year. See Housing Authority (2014).

[13] See: https://www.housingauthority.gov.hk/en/home-ownership/information-for-home-owners/premium-payment-arrangement/premium-statistics/index.html

of transactions on the HOS Secondary Market per year was therefore less than 0.3 percent of the stock of sold TPS units.[14] The reason is that most eligible households can wait to purchase from the government at a discounted price. Buyers on the HOS Secondary market would only purchase if units were similarly discounted. Few TPS households would be willing to sell at this discount, however, as they would not be able to obtain a unit of equivalent value in the open market and are ineligible to purchase in the secondary market.

4 Data and Summary Statistics

In this section, I describe the data and highlight two descriptive facts. First, TPS-eligible household largely did not become private owners with premiums paid during the subsequent two decades. Second, TPS participants were disproportionately larger, younger, and high-income households who were more likely to benefit from a relaxation of income limits and unit allocation rules.

4.1 Hong Kong Population Census

To measure the effects of TPS on estate outcomes, I use restricted-access data from the Hong Kong Population Census and By-census, specifically, the 20% random samples in 2001, 2011 and the 10% random samples in 1996, 2006, 2016. These data provide information about each respondent's age, sex, household composition, employment, and earnings, as well as an indicator for whether the respondent moved in the last five years.[15] Furthermore, these data include identifiers for 136 public rental housing estates, including all 39 estates where residents became eligible to partake in TPS. This allows me to construct a panel of estates for analysis in Section 5.

[14] See: https://www.housingauthority.gov.hk/en/home-ownership/hos-secondary-market/transaction-records/index.html

[15] Real income is deflated using 1996 dollars.

Table 1: Unit ownership of households in TPS estates over time

Year	1996	2001	2006	2011	2016
Share of HHs in unsold TPS units	100.0%	68.9%	42.6%	35.7%	28.1%
Share of HHs in sold TPS units	0.0%	31.1%	57.4%	64.3%	71.9%
TPS premium unpaid, Owner-occupied	0.0%	31.1%	55.6%	62.5%	70.9%
TPS premium unpaid, Rented	0.0%	0.0%	1.8%	1.4%	0.1%
TPS premium paid, Owner occupied	0.0%	0.0%	0.0%	0.3%	0.5%
TPS premium paid, Rented	0.0%	0.0%	0.0%	0.1%	0.4%
Number of households	185962	185641	181876	180022	177413

Notes: Table decomposes ownership status by household in TPS estates. Source: Hong Kong Population Census.

4.2 Trends in Ownership and Leasing in TPS Estates

Table 1 shows the trend in ownership and leasing composition of households in TPS estates. There are three findings. First, a large majority of units in TPS estates were sold immediately after the launch of TPS. By 2006, the share of households residing in sold TPS units had risen to 57.4 percent from zero in 1996. By 2016, the share further increased to 71.9 percent.

Second, nearly 99 percent of sold TPS units were owner-occupied with their premium unpaid. Since the premium must be paid before a TPS owner could sell, let, assign, or otherwise alienate the unit on the open market, this implies that only a tiny proportion of sold TPS units were either rented out or resold on the open market. The number of transactions in HOS Secondary Market was also small, as later shown in Section 3.3. This suggests that most purchasing households did not move away for many years.

Third, the number of households residing in TPS estates fell from roughly 186,000 in 1996 to 177,000 in 2016. Since the number of units in these estates did not change during this time, this decline anticipates our finding below in Section 5 that the TPS reduced the population and number of households in treated estates.

4.3 Who Became TPS Owners?

There is strong evidence that avoidance of household-size-contingent unit allocation rules and means testing requirements motivated many households to purchase TPS units.

Table 2: HH characteristics, sold and unsold units in TPS estates, 2006

	Sold units	Unsold units	Standardized difference
HH size	3.52	2.91	0.45
	(1.3)	(1.36)	
HH income	18668	12853	0.49
	(13157)	(10304)	
Working persons per HH	1.84	1.24	0.54
	(1.16)	(1.09)	
HH with all 60+ y. o.	0.06	0.15	-0.29
	(0.24)	(0.36)	
Single-person	0.06	0.18	-0.36
Nuclear family	0.76	0.71	0.12
Extended family	0.38	0.32	0.17
Non-family	0.08	0.07	0.02
HH size = 1	0.06	0.18	-0.36
HH size = 2	0.16	0.23	-0.16
HH size = 3	0.25	0.25	0.01
HH size = 4	0.32	0.24	0.18
HH size = 5	0.15	0.08	0.23
HH size = 6+	0.06	0.03	0.11
Number of HHs	101112	80764	

Notes: Table shows mean household characteristics in TPS estates in 2006, respectively for TPS buyers and non-buyers.

Table 2 shows mean household characteristics in TPS estates in 2006, respectively for residents in sold and unsold TPS units. Larger and higher-income households, for whom these rules were more binding, were more likely to live in sold TPS units. By contrast, households whose members are all over 60 years old and therefore not subject to means testing requirements are less likely to live in sold TPS units. A government study in 2001 similarly reported that "the sale results of TPS flats were better among households who were paying additional rent, of larger size and with non-elderly members" (Housing Authority 2001). Yeung (2001) presents survey evidence that fear of paying extra rent was an important motivator for TPS purchases.

Another piece of evidence comes from the Official Proceedings of Hong Kong's Legislative

Council. On October 31, 2012, Council member Wong Kwok-kin made the following remark while lobbying the government to expand TPS:

> Many well-off tenants want to buy their own flats through the TPS so as to avoid the trouble of paying double rent or undergoing random checking. However, many well-off tenants are not sitting tenants in the dozens of TPS estates. Therefore, I would like to ask the Secretary: Whether the authorities will study and consider the proposal of giving well-off tenants not living in the existing TPS estates the option to buy PRH flats if they have such a need? (GovHK 2012)

If households bought TPS units to avoid household-size-contingent unit allocation rules and mean testing requirements, then economic theory predicts that some household members will move out and others will increase labor supply after buying TPS units. As we show in the next section, this is indeed the case.

5 Impact of the Tenants Purchase Scheme

In this section, I estimate the effects of TPS using its staggered and incomplete rollout across housing estates. The estimates reveal that TPS reduced total population and average household size in the treated estates, increased average household income, substantially reduced user costs, and did not alter commute times.

5.1 Empirical Strategy

To identify the effects of TPS on estate-level outcomes, I leverage the staggered and incomplete roll-out of the program across estates in dynamic difference-in-differences design.

The analysis sample includes all 39 treated estates and 43 control estates, chosen as follows. I take all public rental housing estates where residents did not become eligible for TPS. Since the estates chosen for TPS tend to be more recently built, I exclude all estates with any buildings constructed before 1980, to ensure that the control estates had similar building features and resident populations. I also exclude all estates with any buildings constructed after 1996, so

that our estimates are not contaminated by influxes of new residents upon the completion of new construction.[16]

I then estimate the following equation:

$$y_{et} = \sum_{\tau \in \mathscr{T}} \beta_\tau \left(T_e \times 1_{t=t_e^*+\tau} \right) + \delta_e + \delta_t + \varepsilon_{et},$$

where e indexes estates, $t \in \{1996, 2001, 2006, 2011, 2016\}$ is the Census year, y_{et} is an estate-level outcome variable, T_e indicates whether estate e was ever treated, t_e^* is the first Census year following treatment for estate e, $\tau \in \mathscr{T} \equiv \{-10, 0, 5, 10, 15\}$ indexes the year relative to t_e^*, and δ_e and δ_t denote estate and year fixed effects. This equation includes year fixed effects and thus controls for confounding city-wide changes in the housing market that contaminates previous estimates of the effects of the TPS program (e.g. Ho and Wong 2006).

Since the timing of TPS introduction was staggered across estates, my main specification uses the interaction-weighted estimator proposed by Sun and Abraham (2020), which computes an average of the cohort-specific average treatment effect on the treated estates, weighted by the shares of each cohort.[17] Standard errors clustered at the estate level are reported.

The β_τ coefficients identify the causal effect of TPS under the assumption that the outcomes of treated estates would have evolved in parallel to those of control estates in the absence of treatment. It is possible to check for pre-treatment trends, since two pre-treatment Census years are available for the later cohort of treated estates. As shown below, the estimates consistently reveal an absence of pre-treatment trends.

The treatment and control estates are broadly similar in pre-treatment characteristics. Each estate houses roughly 4,500 households, or a population of roughly 18,000. Their average household incomes are highly similar (see Online Appendix Table A3). Furthermore, the pre-treatment characteristics of treated estates are highly similar across cohorts. However, treated estates have larger populations and larger average household sizes than control, suggesting that

[16] See Online Appendix Table A1 and A2. Building construction years are collated from four sources: (1) data.gov.hk; (2) Wikipedia; (3) website of the Housing Society; and (4) website of the Housing Authority.

[17] This specification ensures that estimates are not contaminated by treatment effects from other periods when treatment is staggered (Callaway and Sant'Anna 2020; de Chaisemartin and D'Haultfœuille 2020).

there remain systematic differences between the treated and control estates.

For robustness, I report cohort-specific estimates where observations are reweighted using entropy-balancing (Hainmueller 2012), with two goals in mind. First, reweighting the data so that that treated and control estates have the same pre-treatment average household size and average household income enables us to gauge whether observed pre-treatment differences in estate characteristics lead to selection bias. Second, cohort-specific estimates allow us to gauge whether the effects were similar across the cohorts. As reassuringly shown below, cohort-specific estimates using entropy-balancing weights are highly similar to the main estimates.

5.2 Effects on Household Composition

The estimates reveal that TPS altered household composition in treated estates. Total population and average household size both fell. The share of single-person households increased, while the share of extended-family households fell.

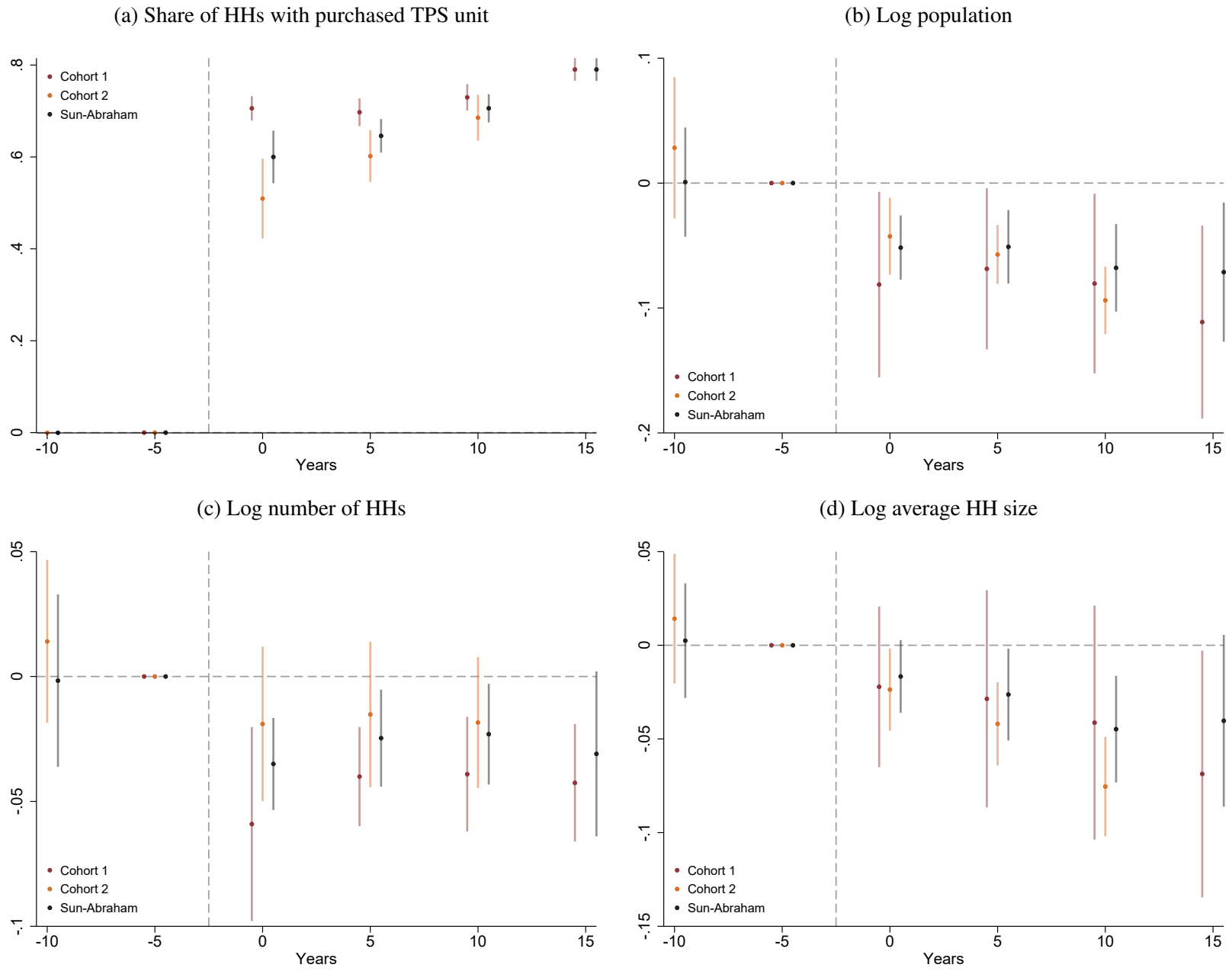
Figure 1 visualizes the effects of TPS on estate composition. Within each panel, the black series plots coefficients from the Sun-Abraham interaction-weighted estimator. The maroon and yellow series plots cohort-specific estimates using entropy-balancing weights, as described above. Year 0 denotes first observed Census year following treatment.

The share of households residing in sold TPS units immediately rose by 60 percent once residents became eligible to purchase TPS units in Year 0. As shown in Panel (a), this share eventually reached 79 percent higher than control in Year 15.

Total population in treated estates immediately declined by 5 log points, as shown in Panel (b). This effect was persistent and reached 7 log points lower than control in Year 15. Since the total population in TPS estates in 1996 was roughly 733,000, these estimates imply that the total population in TPS estates fell by roughly 51,000.

The number of households in treated estates immediately and persistently declined by roughly 2-3 log points, as shown in Panel (c). This decline in the number of households suggests housing units became underutilized as a consequence of TPS sales. These estimates imply that the total number of households in TPS estates fell by roughly 4,000.

Figure 1: Effects of TPS on estate composition



Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham 2020. The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012Hainmuller 2012) that are based on estate-level average household size and income in 1996. Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Average household size in treated estates immediately declined by 0.08, relative to a mean of 4.0 in the pre-treatment year of 1996, as show in Panel (d). This decline widened over time, eventually reaching 0.21, or roughly 5 percent lower than control, in Year 15.

The shares of households with one, two, or three members, while the shares of households with four, five, or six members fell. Furthermore, the share of extended-family households fell by 2.9 percentage points, while the share of single and nuclear family households rose by 0.8 and 1.7 percentage points, respectively (see Online Appendix Figure A3).

These estimated effects are unlikely to be driven by pre-existing trends or selection of estates into treatment. In all of the above panels, we do not detect pre-treatment trends in Year -10. Furthermore, the cohort-specific estimates using entropy-balancing weights are highly similar to the Sun-Abraham estimates, even though they are less precise.[18]

5.3 Effects on Household Income

While TPS reduced household sizes, average household incomes rose in treated estates. The share of households with incomes above the income limits dramatically increased.

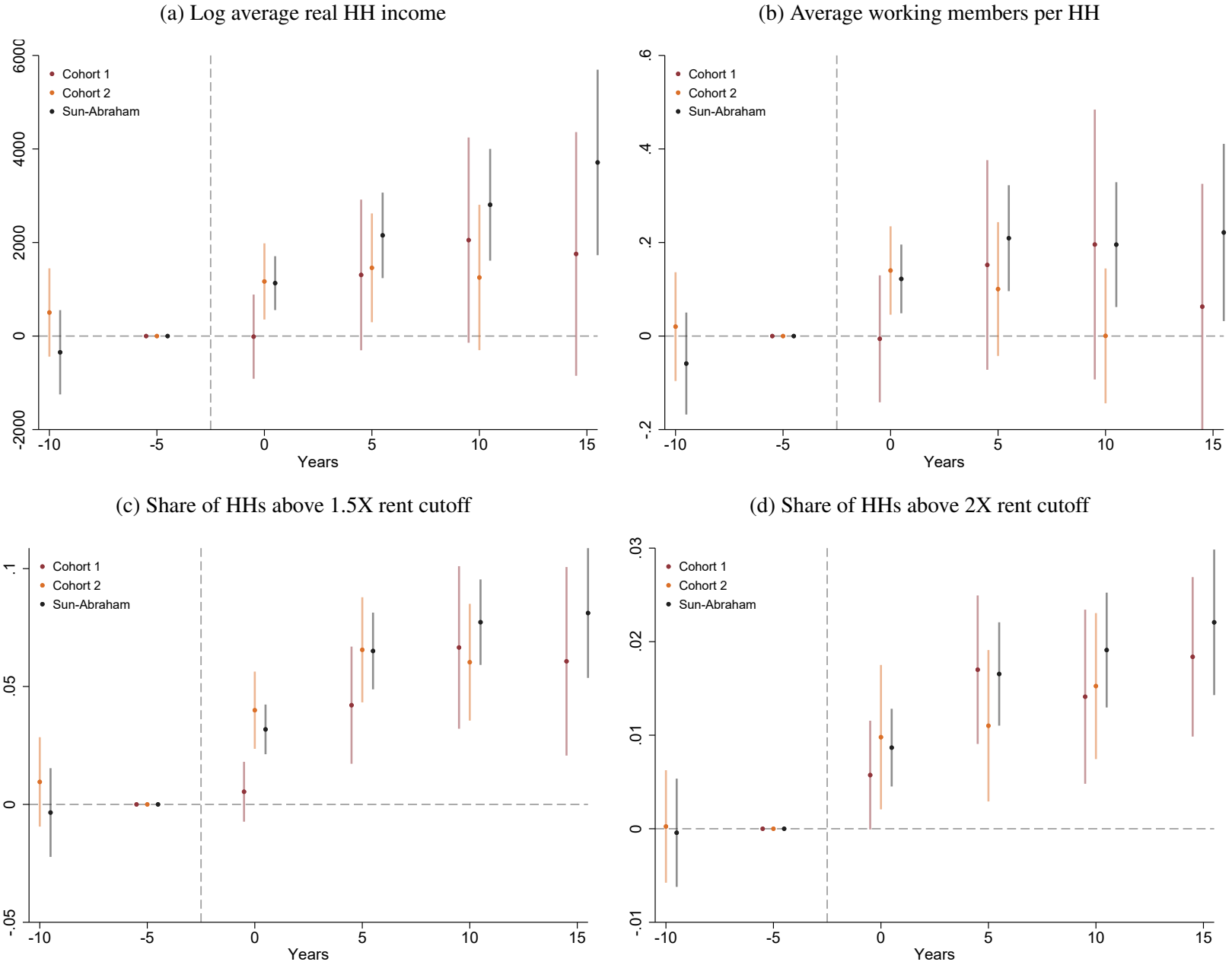
As shown in Figure 2, by Year 0, average real household income in treated estates rose by 1132 dollars per month, or 7 percent relative to the 1996 mean in treated estates. Average real household income continued to diverge between treatment and control estates. By Year 15, average real monthly household income was 3712 dollars (or 23 percent) higher in treated estates.

The average number of working members per household also rose. By Year 5, the average number of working members per household in treated estates increased by 0.2 (or 12 percent). This positive effect persisted until Year 15. Once again, these estimated effects do not appear to be driven by pre-existing trends or selection of estates into treatment.

The share of households above the 1.5X rent income limit rose sharply. By Year 0, the share of households above the 1.5X rent income limit increased by 3.2 percentage points, or

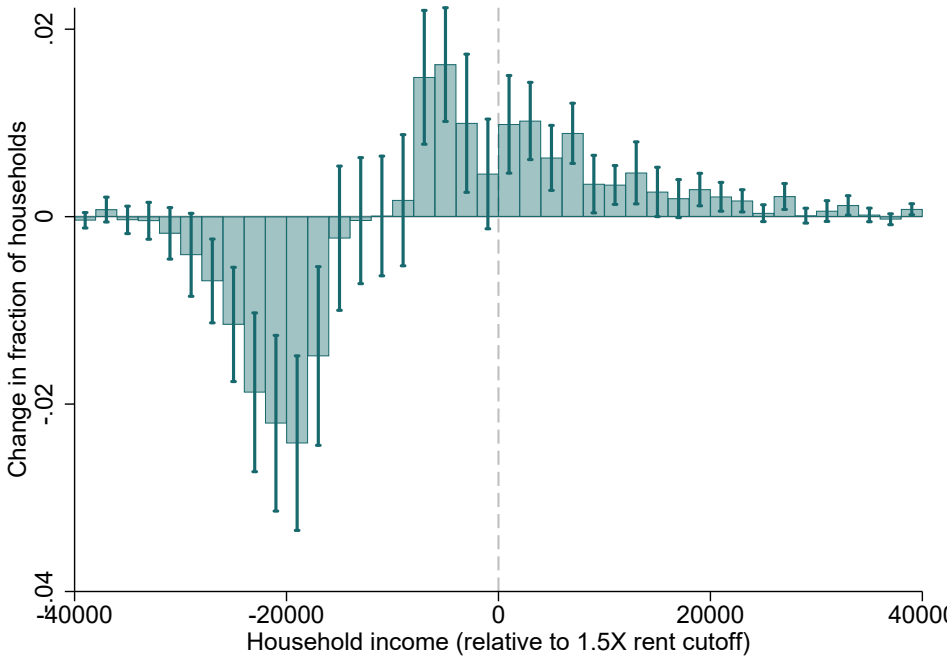
[18]Online Appendix Table A6 tabulates the Sun-Abraham estimates. The first seven columns have already been discussed above. The final column shows that the share of households who moved in the last five years did not appear to have changed in treated estates as a consequence of TPS. However, these estimates are imprecise and therefore inconclusive.

Figure 2: Effects of TPS on estate average HH income



Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample includes all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Figure 3: Effect of TPS on HH income distribution relative to 1.5X rent cutoff



Notes: Figure plots the effect of TPS on the share of households within a given household income bin relative to the 1.5X rent income limit in the second Census following treatment relative to that of the last Census year before treatment, estimated using the interaction-weighted estimator in Sun and Abraham (2020). Standard errors (clustered at the estate level) are shown in bars.

31 percent relative the 1996 mean in treated estates of 10.2 percent. This divergence further widened thereafter. By Year 15, the share of households above the 1.5X rent income limit was 8.1 percentage points (or 80 percent) higher than control.

A similar pattern exists for the share of households above the 2X rent cutoff. By Year 0, the share of households above the 1.5X rent increased by 0.9 percentage points (or 40 percent) in treated estates. By Year 15, the share of households above the 1.5X rent increased by 2.2 percentage points, roughly double the 1996 mean in treated estates.

Figure 3 plots the effect of TPS on the share of households within household income bins.[19] The figure reveals that the share of households with incomes much lower than the 1.5X rent

[19]This exercise relates to a growing literature on bunching at tax kinks, tax notches, and wage floors (Saez 2010; Kleven and Waseem 2013; Kleven 2016; Cengiz et al. 2019; Blomquist et al. 2021).

income limit dramatically fell in treated estates, while the share of households with incomes both above and slightly below the income limit increased.

The lack of a discontinuous response at the cutoff is consistent with the fact that public renter households did not appear to bunch around the income limit even before treatment, as shown in Online Appendix Figure A6. One possible reason is that optimization frictions prevented bunching just below the very large rent notch since it is difficult to coordinate among household members. Another possible reason is measurement error. Consistent with the latter, I observe bunching at round numbers in the data, especially for one-person households (see Online Appendix A6), which may obscure bunching.

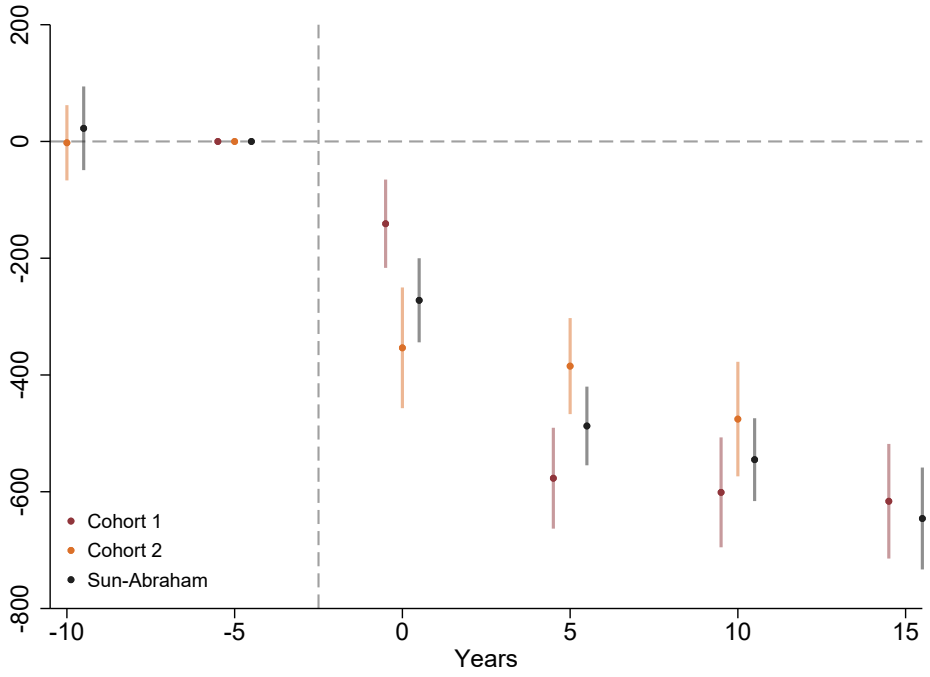
5.4 Effects on User Costs

In theory, TPS could increase the user cost by requiring households to pay a high mortgage, and thereby pressure households to increase their incomes. In practice, however, the average user cost, defined as the sum of monthly rental and mortgage payments, in the TPS estates fell dramatically relative to control, as shown in Figure 4. By Year 0, average user costs fell by $272, or roughly 22 percent of the average rent in treated estates in 1996. The decline deepened and reached $646 by Year 15, or roughly 51 percent. In other words, mortgage payments were lower than counterfactual rent payments immediately after the rollout of TPS and further diverged over time. Pressure to fulfill mortgage obligations thus cannot explain the increase in employment and income documented in the previous subsection.

5.5 Effects on Commute Times

Previous studies have shown that public housing in Hong Kong, both rental and ownership, features significant misallocation due to rationing, as exhibited by larger commuting distances of their residents relative to private-sector counterparts. Consistent with this evidence, Online Appendix Figure A5 shows that TPS did not meaningfully change the average commute times of working persons in the treated households, in any of four demographic groups. This suggests that TPS did not meaningfully reduce misallocation of housing, because of TPS did not make

Figure 4: Effects of TPS on estate average HH user cost



Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample includes all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

housing transferable.

6 Mechanisms

As I have already argued, housing reallocation does not explain the above results. Section 3 showed using property transaction records that very few TPS owners transferred their units on the open market by paying a premium or sold their units on the HOS Secondary Market to a restricted set of buyers. Section 4 showed that roughly 99 percent of residents in TPS estates reported in the Population Censuses that they did not pay the premium and become private owners. Section 5 showed that TPS did not change the commute times in the treated estates despite high levels of spatial misallocation, as documented by Lui and Suen (2011), confirming

that there was little reallocation of housing.

If there was little change in the transferability of occupancy rights, and as argued in Section 5, the effects are not explained by mortgage concerns either, then the observed effects are best explained by the relaxation of the contingency of occupancy rights. This includes the lifting of regular income-testing requirements, which subjected high-income households to 1.5X or double rent, as well as unit allocation rules, which required households whose sizes shrank to move to smaller units. Section 4 provided corroborating evidence that larger and higher-income households were motivated to purchase TPS units in order to avoid income tests. Section 5 showed that TPS nearly doubled the share of households with incomes above the 1.5 times and double rent income limits.

Relaxation of income tests and unit allocation rules can reduce household sizes and increase incomes through three channels. First, it could discourage higher-income and larger households from moving out. Second, it could alter household composition by encouraging low-income household members to move out and high-income household members to remain. Third, it could encourage household members to increase labor supply.

There is suggestive evidence for each of the three channels above. Consistent with reduced outflow of well-off households from treated estates, Yeung (2001) shows survey evidence that TPS reduced demand for other subsidized ownership units. Consistent with reconfiguration of household composition, the estimates show that TPS reduced average household sizes. Finally, evidence suggests that labor supply increased among continuing residents. By Year 10, the average income of women between ages 25-44 rose by 54 percent in treated estates (see Online Appendix Table A7). By contrast, the average income of men in the same age group only rose by 11 percent. The fact that average income increased much more for women than men is consistent with meta-analyses that show that female labor supply is much more elastic (Evers, De Mooij and Van Vuuren 2008). However, the data does not allow me to follow individuals or households over time, so I cannot conclusively distinguish between these channels.

7 Welfare

The results above suggest that TPS on average benefited the sitting tenants, since TPS increased household incomes, reduced household sizes, and reduced user costs in the treated estates. These effects of TPS appear to be driven by relaxed income testing and unit allocation rules, rather than housing allocation and increased wealth. TPS therefore disproportionately benefited well-off tenants for whom these rules were particularly binding.

The effects of TPS on the broader housing market is best understood through the lens of a housing ladder model such as Ortalo-Magné and Rady (2006). At bottom of the ladder are a low-income population queuing to enter public rental housing. At top of the ladder are well-off tenants, who have accumulated sufficient wealth to leave public rental housing for higher-end housing such as subsidized ownership flats.

This lens suggests that while TPS benefited sitting tenants, it likely reduced affordable housing availability for the low-income population. First, our estimates show that TPS reduced total population in treated estates. This implies that new demand for housing at the bottom of the housing ladder was created, because those who moved out must be housed elsewhere. Second, by relaxing unit allocation and income testing rules, TPS likely reduced movement of well-off tenants up the housing ladder. The availability of public rental housing for the low-income population on the PRH waiting list therefore must have correspondingly fallen. In other words, TPS increased the rents of lower-end private rental housing and the waiting times for public rental housing. If Hong Kong relaunched TPS today without modification, as recently proposed by a number of think tanks and Legislative Council members, the housing shortage among Hong Kong's low-income population will likely worsen.[20] A quantitative assessment of whether the benefits of TPS for sitting tenants outweighed the potential negative effects on the low-income population is left for future work.

[20] See Legislative Council Secretariat (2009), GovHK (2012) and Our Hong Kong Foundation (2017, 2019). The Hong Kong government suggests, however, that relaunching TPS will reduce the supply of public rental housing.

8 Conclusion

The nature of the property rights granted to public housing residents differ along two dimensions: (1) the contingency of continuing occupancy on participant income and household size, and (2) the transferability of occupancy rights to other persons. Economic theory suggests that making property rights contingent and non-transferable reduces the welfare of participants, but may enable governments to better target subsidized housing to the needy.

The staggered rollout of Hong Kong's Tenants Purchase Scheme allows for a unique study of the design of public housing occupancy rights, while holding the supply of public housing and the initial allocations fixed. My findings strongly reject the naive view that the supply or the initial allocation of public housing is all that matters for the efficacy of public housing provision. They instead suggest that the design of occupancy rights can fundamentally altered the impact of public housing and should be carefully considered by governments.

First, regular means testing for public housing tenants has very powerful effects on household incomes and composition. As I have shown, the primary effect of TPS was to relax means-testing and unit allocation rules. This increased household income by 23 percent and reduced population in the treated estates by 5-7 percent. TPS therefore had overall positive effects on the resident households, but these effects may have been at the expense of lower-income residents in the public housing wait list.

Second, unlike the privatization of Chinese state employee housing studied by Wang (2011, 2012), the conversion of public rental units into ownership units in Hong Kong failed to reduce housing misallocation. The reason is that a hefty premium was required before units could be freely transferred; this prevented the emergence of a liquid secondary market. When privatizing public housing, it is undesirable to restrict resale and leasing of subsidized ownership units by requiring the payment of a hefty premium as Hong Kong has. However, mild and short-term restrictions on resale and leasing, as implemented in Britain's Right-to-buy policy and in Singapore's HBD system, may be useful in curbing harmful speculative activity and targeting households in need.

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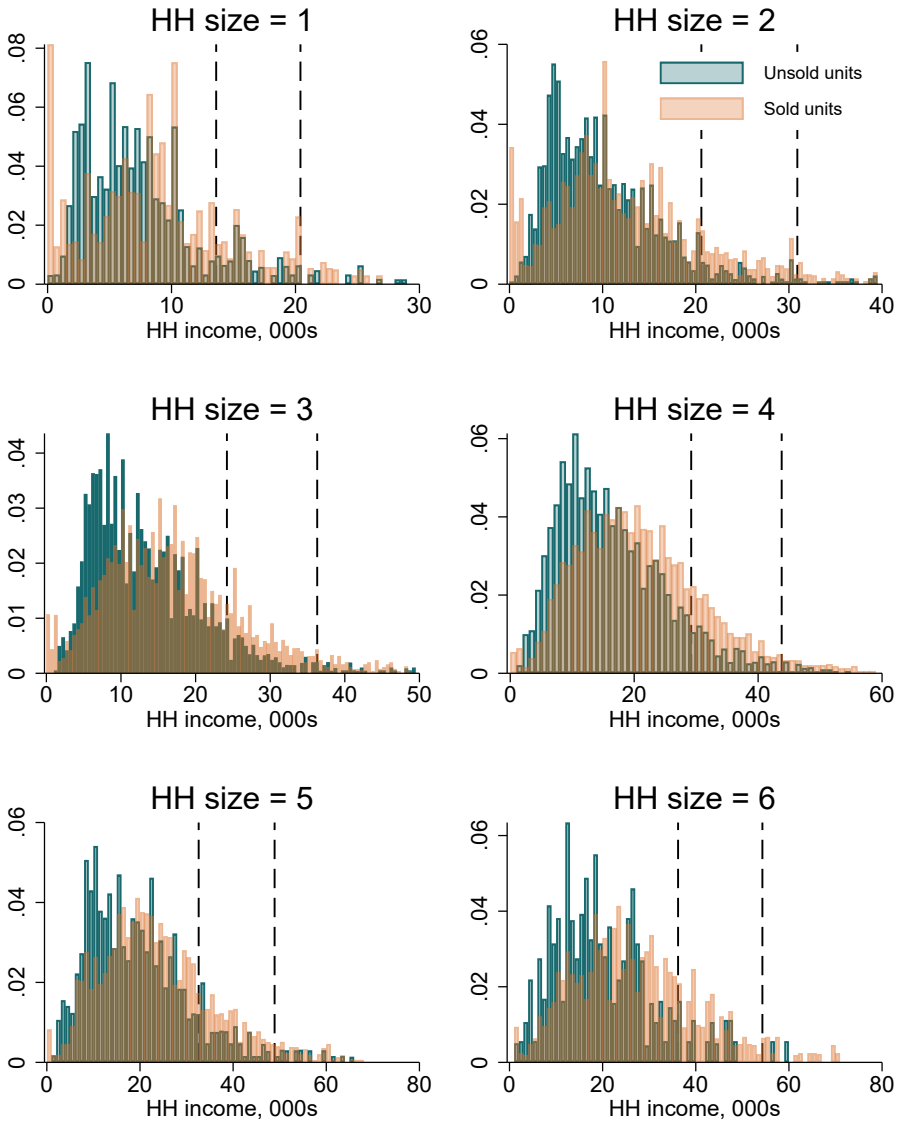
Online Appendix

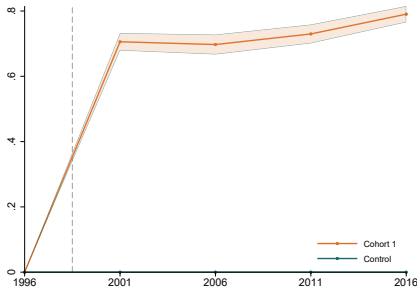
Figure A1: HH income distribution by household size, sold vs unsold units, 2006



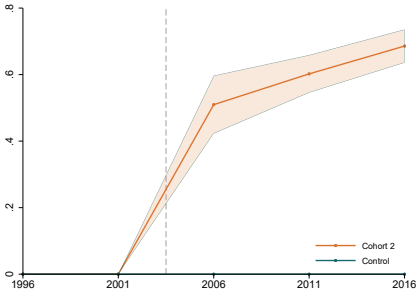
Notes: Figure plots the distribution of household income in TPS estates in 2006 by household size, respectively for sold and unsold units. The 1.5X and 2X rent income limits are plotted in dashed vertical lines. Households with all members above age 60 are excluded.

Figure A2: Trends in housing estate outcomes, treated vs weighted control estates

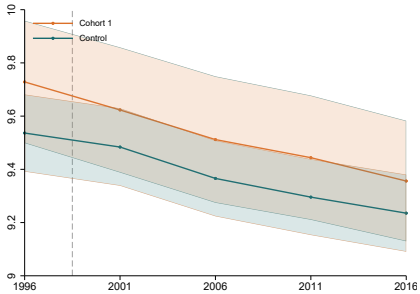
(a) Share of HHs in TPS - Cohort 1



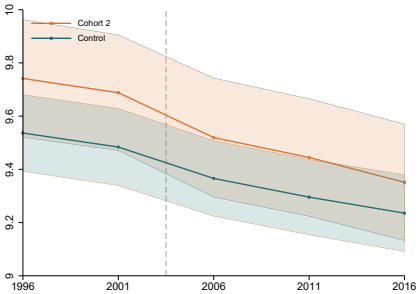
(b) Share of HHs in TPS - Cohort 2



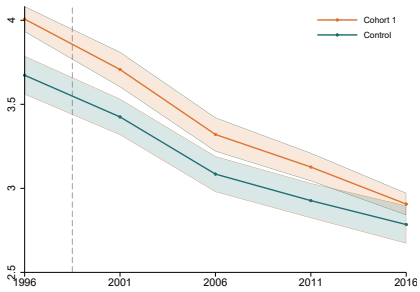
(c) Log population - Cohort 1



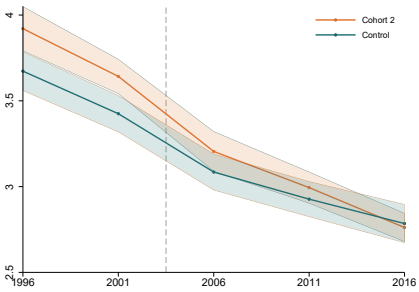
(d) Log population - Cohort 2



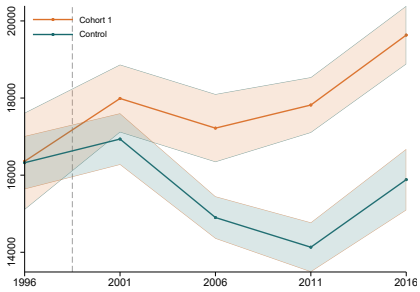
(e) Average HH size - Cohort 1



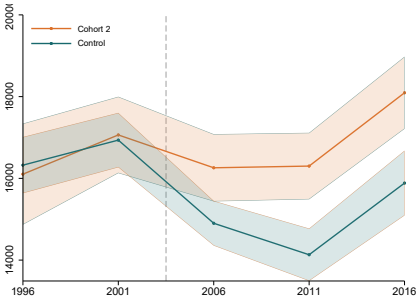
(f) Average HH size - Cohort 2



(g) Average HH income - Cohort 1

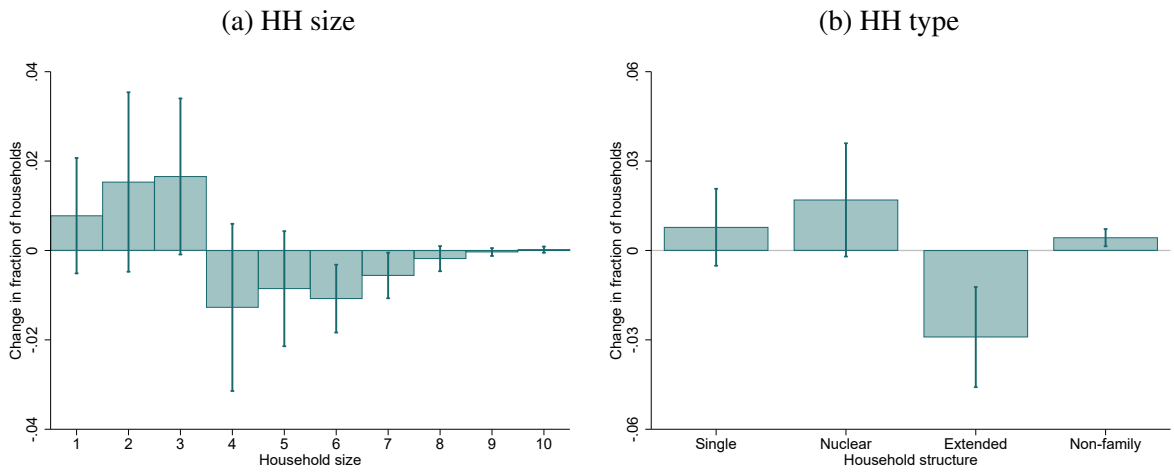


(h) Average HH income - Cohort 2



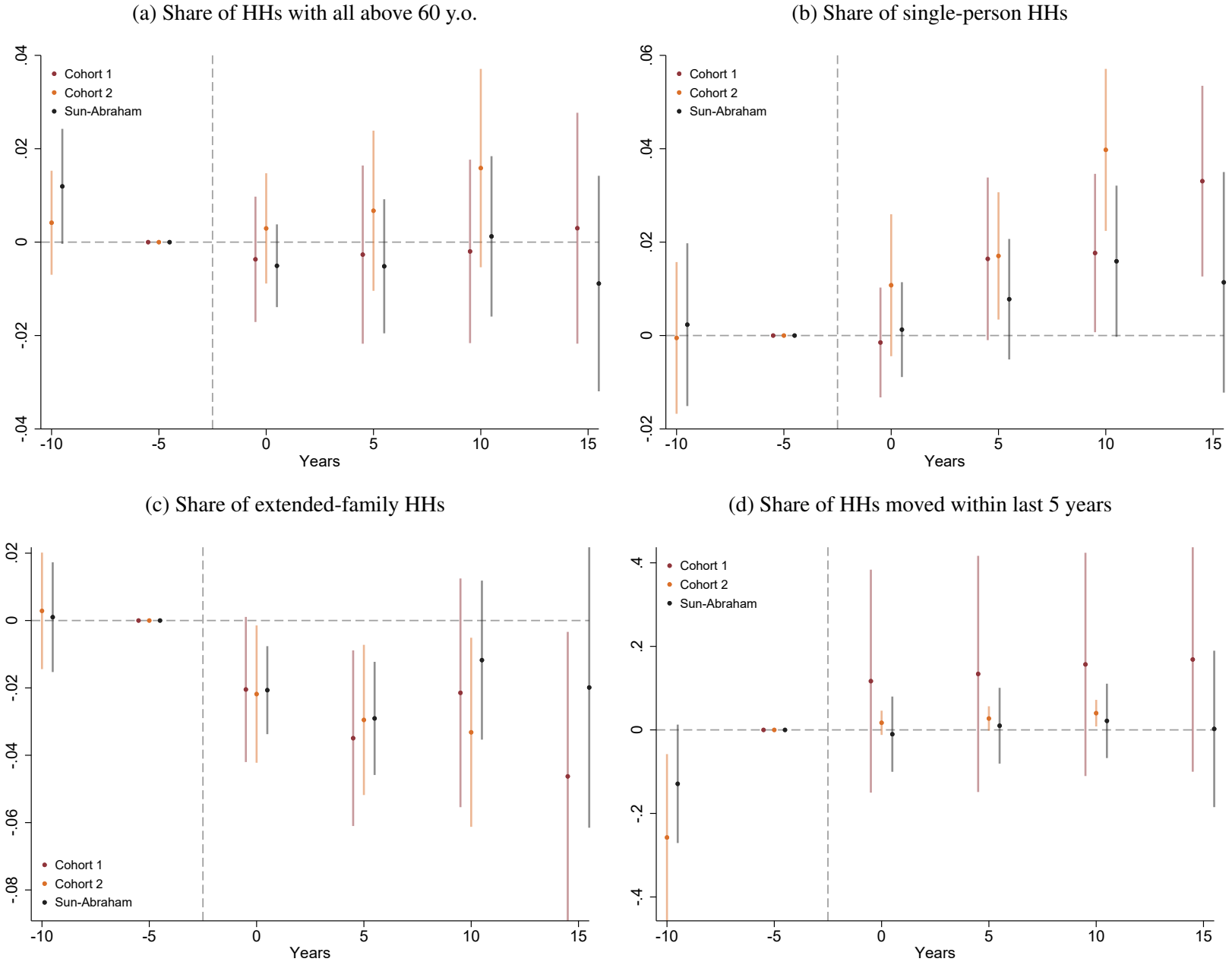
Notes: Each panel shows the trend in mean estate characteristics, separately for the two treated cohorts and their respective controls, whose means are computed with entropy balancing weights (Hainmuller 2012) that are based on estate-level average household size and income in 1996. Sample includes all estates where all buildings were built after 1979 and before 1996. Standard errors are shown in the shade area.

Figure A3: Effect of TPS on distribution of household types



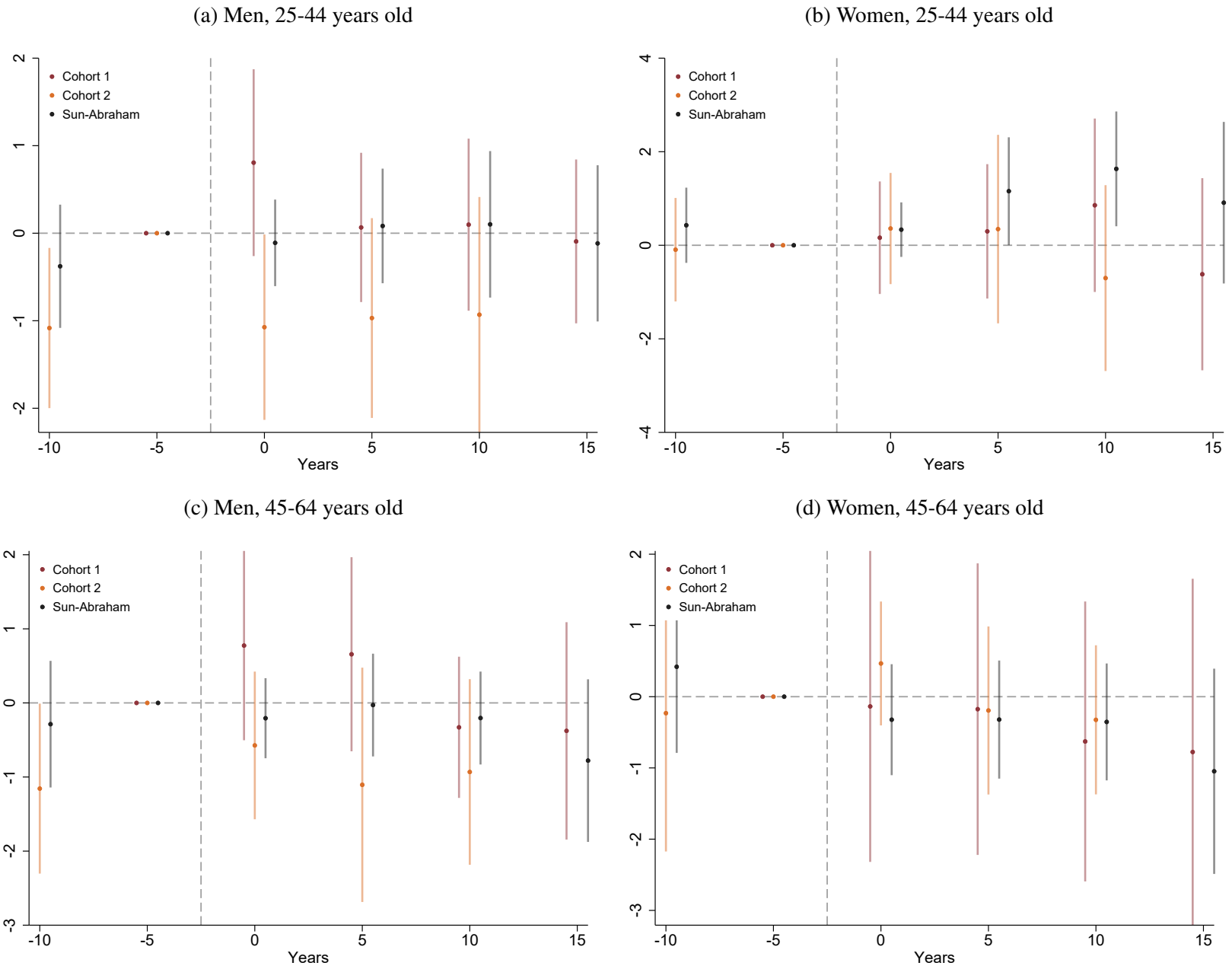
Notes: Figure plots the effect of TPS on the share of households with a given household type in the second Census year following treatment relative to that of the last Census year before treatment, estimated using the interaction-weighted estimator in Sun and Abraham (2020). Standard errors (clustered at the estate level) are shown in bars. Single households include only one person. Nuclear households include a couple and any of their children. Extended-family households include a nuclear family and additional relatives, e.g. at least one parent of the couple.

Figure A4: Effect of TPS on estate composition, additional outcomes



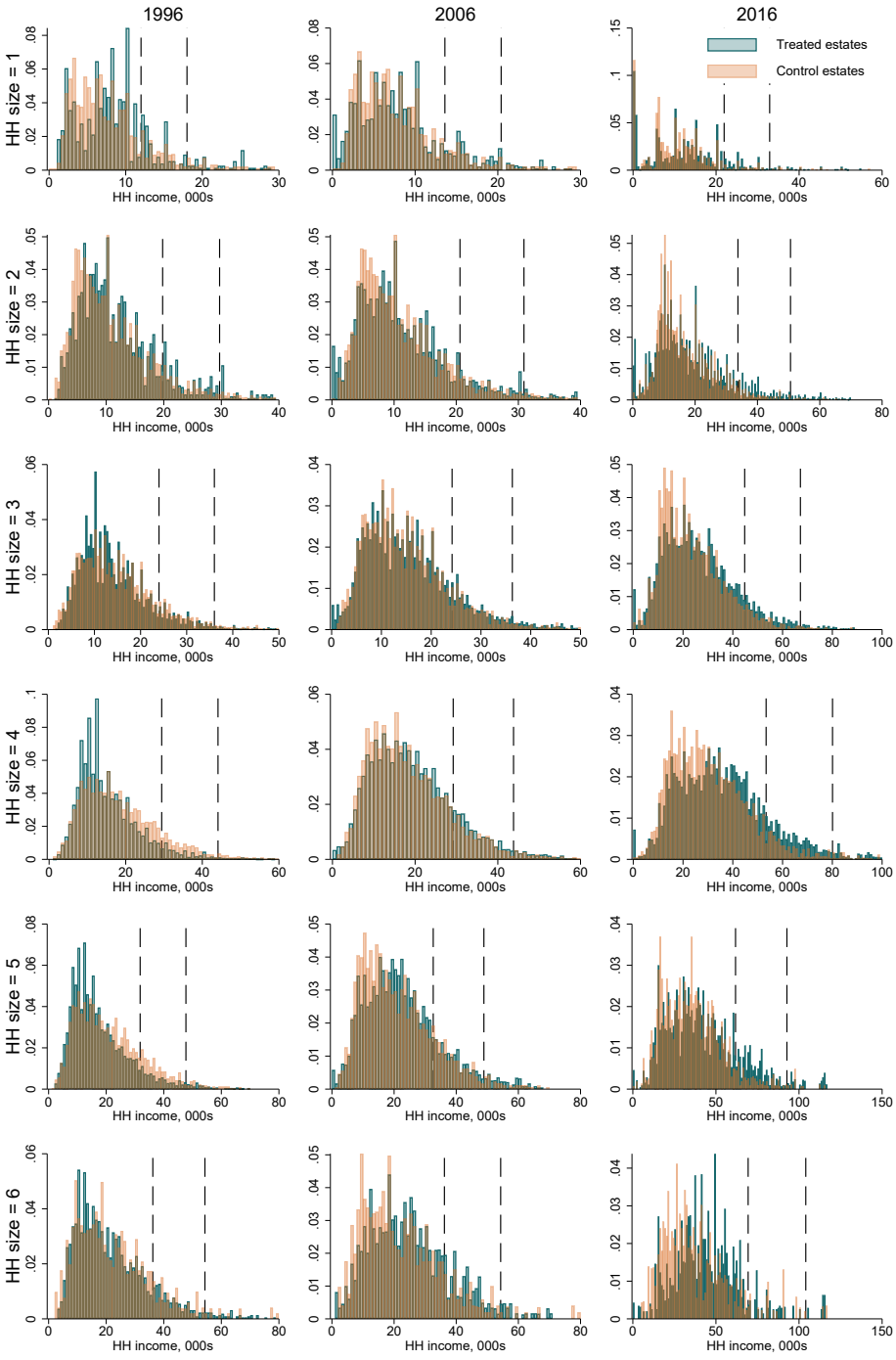
Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Figure A5: Effects of TPS on estate average commute minutes



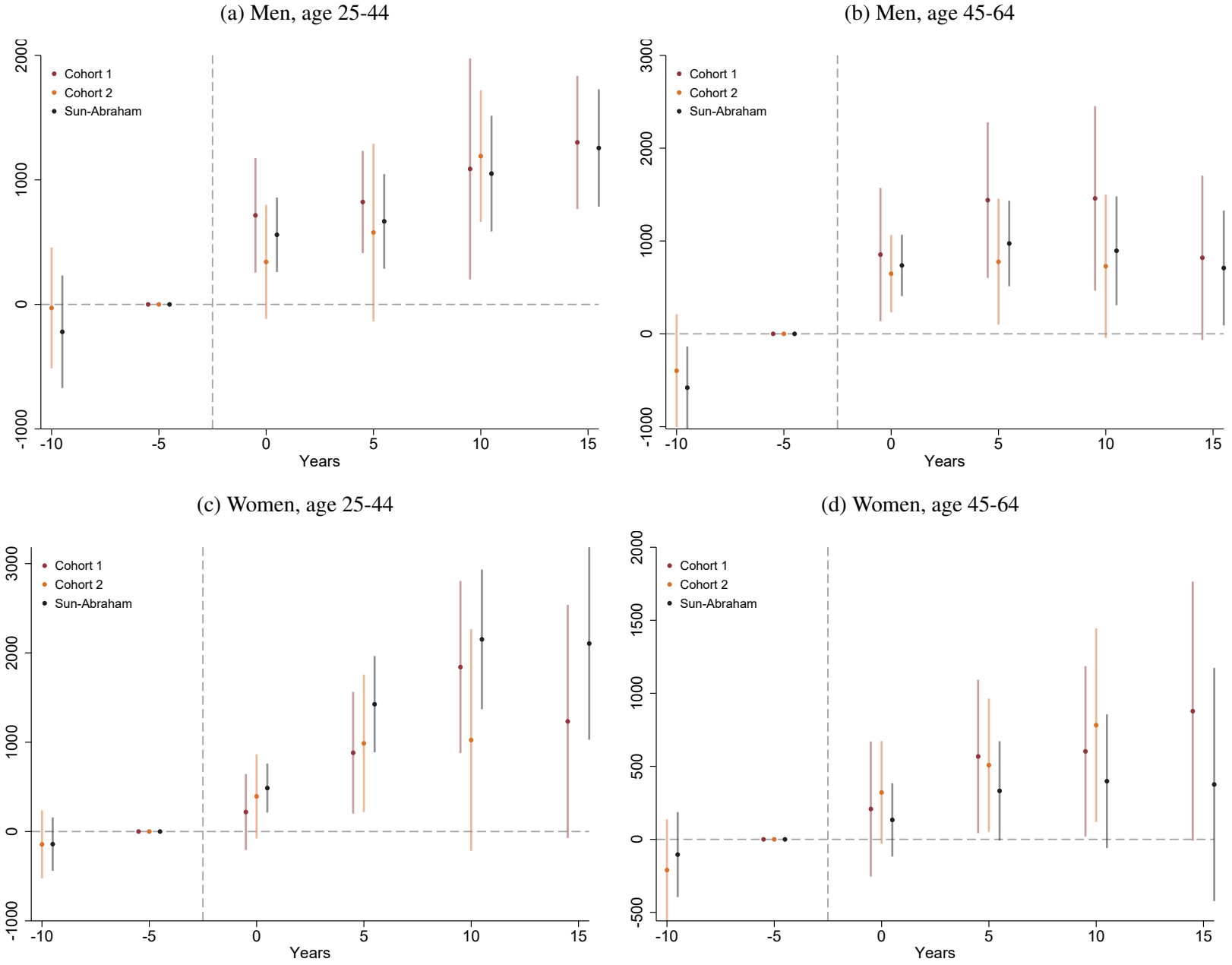
Notes: Commute time is defined as the time for a person to drive from the estates to their workplace, as defined by Google's Distance Matrix API with time set at 8:00am August 25, 2020. The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample includes all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Figure A6: HH income distribution by household size, treated vs control estates



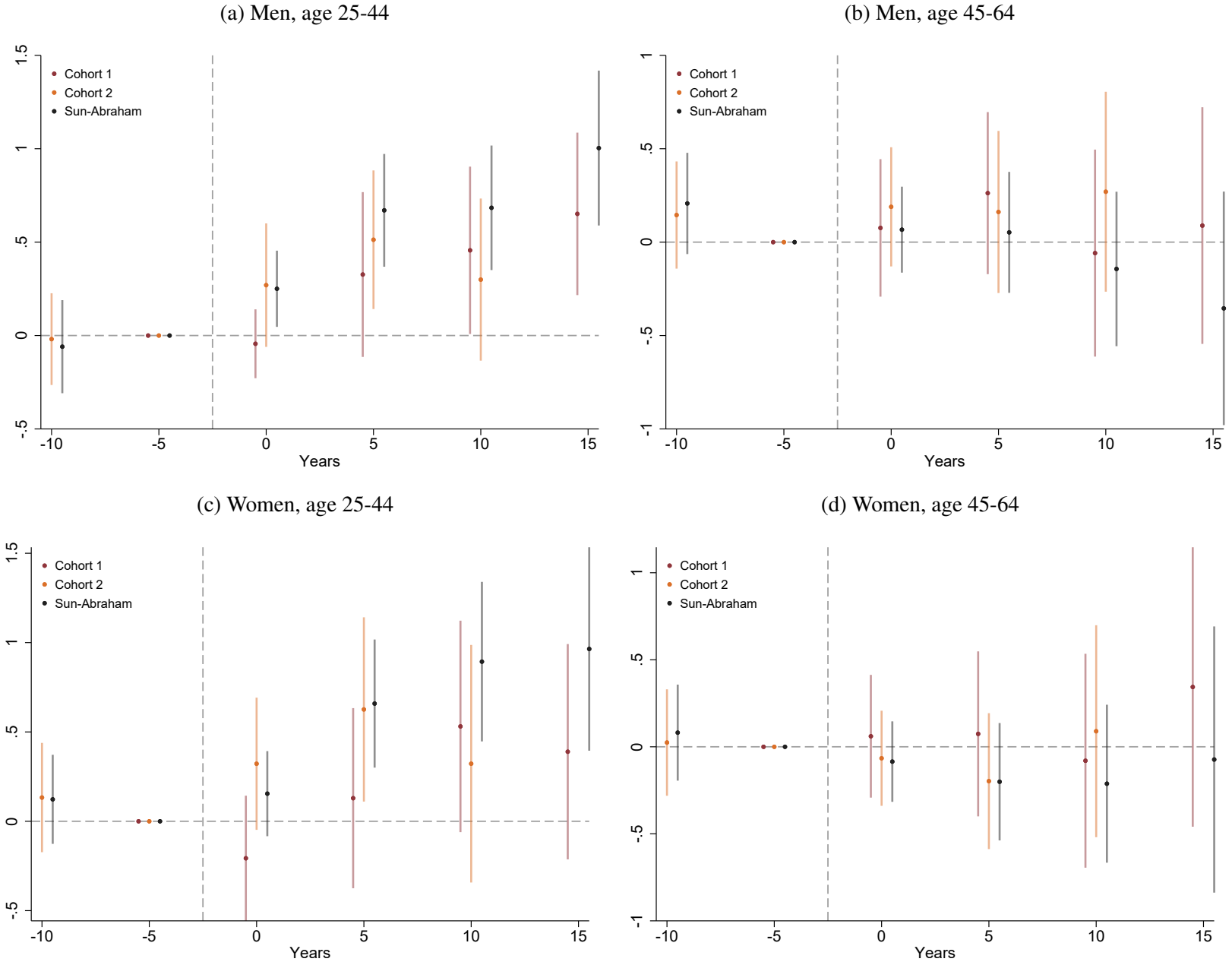
Notes: Figure plots the distribution of household income in treated and control estates, respectively in 1996, 2006, and 2016. The 1.5X and 2X rent income limits are plotted in dashed vertical lines. Households with all members above age 60 are excluded.

Figure A7: Effect of TPS on estate average income by demographic group



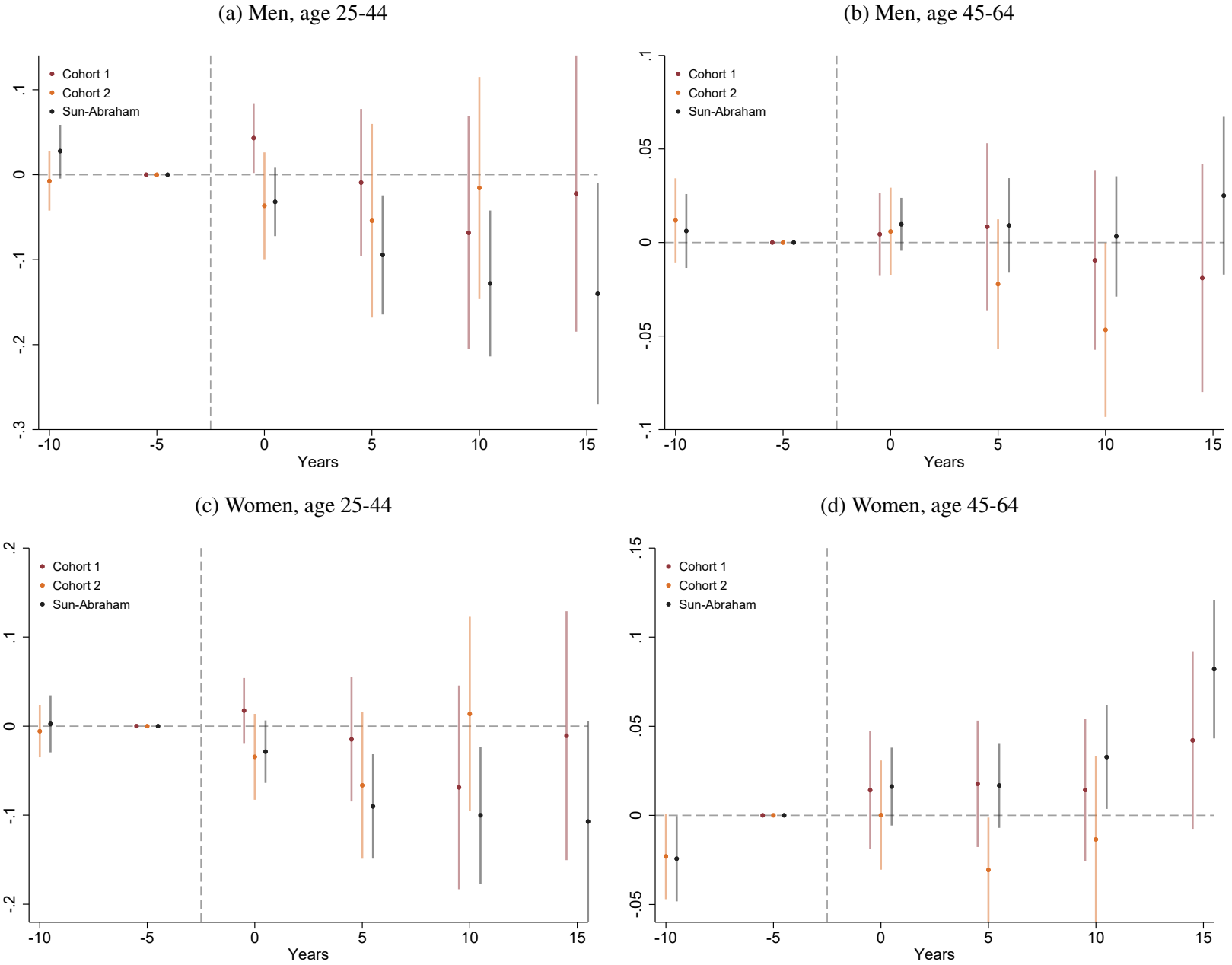
Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Figure A8: Impact of TPS on estate average schooling by demographic group



Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Figure A9: Impact of TPS on share married by demographic group



Notes: The black series plots coefficients from the interaction-weighted estimator in Sun and Abraham (2020). The maroon and yellow series plots cohort-specific coefficients, estimated with entropy balancing weights (Hainmueller 2012) that are based on estate-level average household size and income in 1996. Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars.

Table A1: Sample restrictions

	Treated	Control
All estates observed in Census years 1996-2016	39	97
No construction after 1996	39	72
No construction before 1980	39	43

Notes: Table counts the number of estates identified in the data and after imposing sample restrictions.

Table A2: List of estates

Treated estates, Cohort 1	Treated estates, Cohort 2	Control estates	
Cheung On Estate	Yiu On Estate	Ap Lei Chau Estate	Lower Wong Tai Sin (2) Estate
Choi Ha Estate	Cheung Fat Estate	Butterfly Estate	Lung Hang Estate
Chuk Yuen North Estate	Cheung Wah Estate	Chak On Estate	Mei Lam Estate
Fu Heng Estate	Fu Shin Estate	Cheung Hang Estate	On Ting Estate
Fung Tak Estate	Hing Tin Estate	Choi Fai Estate	On Yam Estate
Fung Wah Estate	King Lam Estate	Choi Yuen Estate	Sam Shing Estate
Heng On Estate	Kwai Hing Estate	Chuk Yuen South Estate	Sha Kok Estate
Hin Keng Estate	Kwong Yuen Estate	Chun Shek Estate	Shek Wai Kok Estate
Kin Sang Estate	Lei Cheng Uk Estate	Hau Tak Estate	Shun Tin Estate
Tai Wo Estate	Lei Tung Estate	Hing Man Estate	Siu Sai Wan Estate
Tak Tin Estate	Leung King Estate	Jat Min Chuen	Sun Chui Estate
Tin King Estate	Long Ping Estate	Ka Fuk Estate	Sun Tin Wai Estate
Tin Ping Estate	Lower Wong Tai Sin (1) Estate	Ka Wai Chuen	Tai Yuen Estate
Tsui Wan Estate	Nam Cheong Estate	Kai Yip Estate	Tin Shui (1) Estate
Wah Kwai Estate	Po Lam Estate	Kwong Fuk Estate	Tin Shui (2) Estate
Wah Ming Estate	Pok Hong Estate	Kwong Tin Estate	Tin Yiu (1) Estate
Wan Tau Tong Estate	Shan King Estate	Kwun Tong Garden Estate	Tin Yiu (2) Estate
Yiu On Estate	Tai Ping Estate	Lai Kok Estate	Tsz Man Estate
	Tsing Yi Estate	Lai On Estate	Wang Tau Hom Estate
	Tsui Lam Estate	Lee On Estate	Wu King Estate
	Tsui Ping North Estate	Lok Wah North Estate	Yiu Tung Estate
	Tung Tau (2) Estate	Lok Wah South Estate	

Notes: Table tabulates all estates included in analysis.

Table A3: Estate characteristics, treated vs control estates, 1996

	Treated estates	Control estates	Standardized difference
Year built	1989	1986	0.57
	(2)	(5)	
Population	18794	15318	0.5
	(7722)	(6232)	
Number of HHs	4768	4167	0.33
	(1965)	(1639)	
Average HH size	4.0	3.7	0.89
	(0.3)	(0.4)	
HH with all 60+ y. o.	0.07	0.09	-0.39
	(0)	(0)	
Working persons per HH	1.62	1.63	-0.04
	(0.27)	(0.24)	
Average HH income	16221	16323	-0.04
	(2782)	(2307)	
Average rent	1255	1297	-0.17
	(180)	(281)	
HH above 1.5X rent cutoff	0.10	0.12	-0.33
	(0.05)	(0.04)	
HH above 2X rent cutoff	0.02	0.03	-0.18
	(0.01)	(0.01)	
Number of estates	39	43	

Notes: Table shows mean estate characteristics in 1996, respectively for TPS and non-TPS estates.

Table A4: Estate HH composition, treated vs control estates, 1996

	Treated estates	Control estates	Standardized difference
Single-person HH	0.07	0.09	-0.32
	(0.05)	(0.05)	
Nuclear family HH	0.70	0.68	0.12
	(0.11)	(0.09)	
Extended family HH	0.22	0.22	0.09
	(0.09)	(0.07)	
Non-family HH	0.005	0.007	-0.37
	(0.005)	(0.007)	
HH size = 1	0.07	0.09	-0.32
	(0.05)	(0.05)	
HH size = 2	0.09	0.14	-1.11
	(0.04)	(0.06)	
HH size = 3	0.18	0.20	-0.62
	(0.03)	(0.04)	
HH size = 4	0.33	0.30	0.51
	(0.08)	(0.05)	
HH size = 5	0.20	0.18	0.58
	(0.04)	(0.05)	
HH size = 6	0.09	0.07	0.64
	(0.03)	(0.03)	
HH size = 7	0.03	0.02	0.51
	(0.02)	(0.02)	
HH size = 8	0.01	0.01	0.47
	(0.01)	(0.01)	
HH size = 9	0.003	0.002	0.43
	(0.003)	(0.002)	
HH size = 10	0.001	0.001	0.06
	(0.002)	(0.002)	
Number of estates	39	43	

Notes: Table shows mean estate characteristics in 1996, respectively for TPS and non-TPS estates.

Table A5: Estate characteristics, treatment vs weighted controls, 1996, by treatment cohort

	Cohort 1			Cohort 2		
	Treated estates	Control estates	Standardized difference	Treated estates	Control estates	Standardized difference
Year built	1989	1989	0	1988	1988	0
	(1)	(5)		(2)	(5)	
Population	18576	15544	0.47	18980	15945	0.44
	(7603)	(5207)		(8005)	(5420)	
Number of HHs	4636	3889	0.46	4882	4072	0.46
	(1876)	(1310)		(2077)	(1369)	
Average HH size	4.0	4.0	0	3.9	3.9	0
	(0.2)	(0.4)		(0.3)	(0.4)	
HH with all 60+ y. o.	0.06	0.04	0.61	0.07	0.05	0.43
	(0.04)	(0.03)		(0.05)	(0.04)	
Working persons per HH	1.63	1.68	-0.18	1.61	1.65	-0.14
	(0.26)	(0.29)		(0.28)	(0.27)	
Average HH income	16360	16355	0	16103	16048	0.02
	(2722)	(2689)		(2894)	(2466)	
Average rent	1278	1328	-0.23	1236	1279	-0.18
	(147)	(279)		(206)	(262)	
HH above 1.5X rent cutoff	0.10	0.10	0.03	0.10	0.10	0.04
	(0.05)	(0.05)		(0.05)	(0.04)	
HH above 2X rent cutoff	0.02	0.02	0.23	0.02	0.02	0.15
	(0.01)	(0.01)		(0.01)	(0.01)	
Number of estates	18	43		21	43	

Notes: Table shows mean estate characteristics in 1996, separately for the two treated cohorts and their respective controls, whose means are computed with entropy balancing weights (Hainmuller 2012) that are based on estate-level average household size and income in 1996.

Table A6: Effect of TPS on estate HH composition

	(1) Share of TPS units sold	(2) Log population	(3) Log num. of HH	(4) Average HH size	(5) Share of single-person HH	(6) Share of nuclear family HH	(7) Share of extended family HH	(8) Share of HH moved in last 5 years
t = -10	0.00~	0.00	-0.002	0.03	0.002	-0.004	0.001	-0.13~
	(0.00)	(0.02)	(0.018)	(0.06)	(0.009)	(0.009)	(0.008)	(0.07)
t = 0	0.60**	-0.05**	-0.035**	-0.08*	0.001	0.018*	-0.021**	-0.01
	(0.03)	(0.01)	(0.009)	(0.03)	(0.005)	(0.007)	(0.007)	(0.05)
t = 5	0.65**	-0.05**	-0.025*	-0.13**	0.008	0.017~	-0.029**	0.01
	(0.02)	(0.01)	(0.010)	(0.04)	(0.007)	(0.010)	(0.009)	(0.05)
t = 10	0.71**	-0.07**	-0.023*	-0.19**	0.016~	-0.008	-0.012	0.02
	(0.02)	(0.02)	(0.010)	(0.04)	(0.008)	(0.012)	(0.012)	(0.05)
t = 15	0.79**	-0.07*	-0.031~	-0.21**	0.011	0.006	-0.020	0.00
	(0.01)	(0.03)	(0.017)	(0.07)	(0.012)	(0.021)	(0.021)	(0.10)
Treated mean, 1996	0.00	18794	4768	3.96	0.07	0.70	0.22	0.14
R2	0.98	0.99	1.00	0.94	0.87	0.88	0.81	0.50
Num. of estate-years	410	410	410	410	410	410	410	410
Num. of estates	82	82	82	82	82	82	82	82

Notes: Table shows coefficients from the interaction-weighted estimator in Sun and Abraham (2020). Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars, with ~ = significant at the 10% level, * = significant at the 5% level, and ** = significant at the 1% level.

Table A7: Effect of TPS on estate HH income distribution

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average real HH income	Share of HH above 1.5X rent cutoff	Share of HH above 2X rent cutoff	Working persons per HH	Average real personal income			
					Men, 25-44 y.o.	Women 25-44 y.o.	Men, 45-64 y.o.	Women, 45-64 y.o.
t = -10	-347	-0.003	0.000	-0.06	-220	-141	-580*	-104
	(460)	(0.010)	(0.003)	(0.06)	(231)	(152)	(227)	(148)
t = 0	1132**	0.032**	0.009**	0.12**	559**	486**	737**	133
	(294)	(0.005)	(0.002)	(0.04)	(153)	(140)	(169)	(128)
t = 5	2153**	0.065**	0.017**	0.21**	667**	1426**	973**	332~
	(466)	(0.008)	(0.003)	(0.06)	(194)	(275)	(235)	(174)
t = 10	2807**	0.077**	0.019**	0.20**	1050**	2151**	895**	398~
	(610)	(0.009)	(0.003)	(0.07)	(237)	(399)	(299)	(234)
t = 15	3712**	0.081**	0.022**	0.22*	1256**	2105**	710*	376
	(1012)	(0.014)	(0.004)	(0.10)	(240)	(550)	(316)	(407)
Treated mean, 1996	16221	0.102	0.023	1.62	9815	3985	6830	1959
R2	0.71	0.70	0.63	0.67	0.71	0.82	0.63	0.66
Num. of estate-years	410	410	410	410	410	410	410	410
Num. of estates	82	82	82	82	82	82	82	82

Notes: Table shows coefficients from the interaction-weighted estimator in Sun and Abraham (2020). Sample is all estates where all buildings were built after 1979 and before 1996. Year 0 denotes first observed Census year following treatment. Standard errors (clustered at the estate level) are shown in bars, with ~ = significant at the 10% level, * = significant at the 5% level, and ** = significant at the 1% level.