

The Geography of Public Housing and the Dynamics of City Structure*

Filip Sangild Beck¹, David Jinkins¹, and Ismir Mulalic¹

¹Copenhagen Business School

April 30, 2026

PRELIMINARY AND INCOMPLETE

Abstract

This paper examines how public housing impacts urban structure over time. Exploiting individual-level panel data from Denmark and a quasi-experimental privatization of public housing, we document how public housing shapes the dynamics of city structure. We develop and estimate a dynamic quantitative urban model with endogenous amenities and both private and publicly allocated housing and find that reductions in public housing substantially amplify gentrification patterns by altering household sorting, housing prices, and local amenities.

Keywords: Public housing, gentrification, quantitative spatial models, endogenous amenities.

*We would like to thank Marcus Asplund and seminar participants at Copenhagen Business School for comments and suggestions. The authors thank Statistics Denmark for providing the data. We gratefully acknowledge financial support from the ROCKWOOL Foundation. The usual disclaimer applies.

1 Introduction

Since the late twentieth century, urban gentrification has reshaped many major cities across high-income countries (Hwang and Lin, 2016). Although no single, universally accepted definition exists (Lees et al., 2008), gentrification is commonly characterized by demographic shifts within affected neighborhoods, the displacement of lower-income households by higher-income households, and sustained increases in housing prices (Guerrieri et al., 2013; Baum-Snow and Hartley, 2020).¹ The gentrification process is also related to the emergence of new consumption hubs, marked by a growing supply of amenities – such as restaurants, bars, and a wide range of entertainment venues – that disproportionately cater to higher-income residents (Glaeser et al., 2018; Behrens et al., 2024). However, it remains unclear why some cities experience more extensive gentrification than others and what factors determine the pace at which these transformations unfold.

We know even less about whether, and through which mechanisms, rent control policies interact with the gentrification process.² Regulation in housing markets, particularly in the form of rent control, has been shown to reduce housing supply either through decreases in quantity or deterioration in quality (Olsen, 1988; Diamond et al., 2019; Kholodilin, 2024). Moreover, distortions arising from the inefficient allocation of housing across households can generate additional welfare losses (Glaeser and Luttmer, 2003; Buurma-Olsen et al., 2024). As a result, urban housing markets are shaped by the interaction between market forces and public policy (Sims, 2007; Autor et al., 2014; Diamond and McQuade, 2019). Various forms of rent regulation, including public housing provision, can therefore operate as barriers to gentrification and substantially influence both the extent and the pace at which gentrification unfolds. This paper examines how rent control, and publicly provided housing in particular, affects the dynamics of urban gentrification.

This paper combines individual panel data for the Copenhagen Metropolitan Area (CMA) from 1986 to 2016 with a quasi-experimental setting – the privatization of publicly owned housing by the City of Copenhagen – to provide evidence on how public housing shapes the dynamics of urban gentrification. The CMA is an ideal context for this analysis. First, it contains a substantial public housing sector, accounting for approximately 20% of the total residential housing stock. Second, like many cities worldwide, the CMA has undergone pronounced gentrification in recent decades. Third, following a severe municipal budget crisis, the City of Copenhagen unexpectedly privatized its municipally owned public housing, which at the time represented about 7% of the municipality’s residential housing stock.

This policy shock generated an unexpected and sizable reduction in the supply of public housing. We exploit this quasi-experimental shift in the availability of rent-regulated units to estimate our model and examine how regulated rental housing affects the spatial patterns of gentrification. The quasi-natural experiment, combined with high-quality Danish registry

¹Well before the term *gentrification* was introduced, analogous processes occurred, for example, Haussmann’s redesign of Paris (1850s–1870s), which replaced dense working-class districts with boulevards and bourgeois housing. Contemporary observers such as the poet Charles Baudelaire noted the resulting social and spatial dislocation.

²Modern rent control was first introduced in the United Kingdom in 1915 through the Increase of Rent and Mortgage Interest (War Restrictions) Act, prompted by rent strikes in Glasgow. Vienna followed shortly after, implementing rent freezes in 1917 under the Austro-Hungarian Empire, later expanded during the early Austrian Republic.

data, enables analysis at a granular geographic scale. We begin by documenting three stylized facts.

First, the reduction in public housing provision induces a gradual shift in neighborhood composition, reflected in a rising share of highly educated residents and increasing disposable incomes. Second, these sorting patterns place upward pressure on local housing prices. Third, changes in access to public housing significantly reshape the provision of consumption amenities: the number of supermarkets, greengrocers, and kiosks increases, whereas the number of restaurants, general practitioners, and primary schools decreases.

We combine the reduced-form evidence with a dynamic quantitative urban model that enables us to analyze the general equilibrium effects of public housing in a setting where private and public housing coexist, and where access to public housing is rationed by non-price allocation mechanisms such as lotteries. While private markets clear via the price mechanism, the market for public housing clears via a household-type dependent average utility shifter. These shifters are a reduced form of the underlying mechanism via which public housing is offered to some individuals but not others.

Public housing allocation affects neighborhoods through endogenous amenities. In our model, consumers consume not only in their own residential location but also in nearby locations. Firms endogenously sort to take advantage of home market effects, catering to the spending patterns of nearby residents. Building public housing in a location changes local household types, and thereby the products that are offered by local firms. When local firms change, it changes the relative attractiveness of living nearby across household types.

We take advantage of the Danish micro data to estimate the structural parameters of this model. We use the estimated model to assess the relative importance of public housing for the dynamics of gentrification. A natural question is how much of the observed changes in household sorting, housing prices, and the provision of consumption amenities is related to the presence and location of public housing. To address this, we conduct a series of model-based counterfactual exercises.

We simulate outcomes under alternative levels of public housing provision. In one scenario, all public housing is converted to private housing. In another, we move all public housing to one of the richest municipalities in Denmark, Gentofte municipality, just to the north of the central city. We show that removing public housing, and moving it out of the core of the city to Gentofte both serve to increase gentrification. In our privatization counterfactual, the ratio of rental prices in the core of Copenhagen rises by 29% against the periphery.

Related Literature Our paper is related to a number of literatures. First, our paper contributes to the spatial equilibrium literature by studying the effect of the provision of public housing on the rate and scale of neighborhood change. We build on the literature on the drivers of urban gentrification (Gyourko et al., 2006; Hwang and Lin, 2016; Brueckner and Rosenthal, 2009; Ellen and O’Regan, 2011; Lee et al., 2022; Baum-Snow and Hartley, 2020; Guerrieri et al., 2013; Couture and Handbury, 2020; Behrens et al., 2024; Su, 2022; Moreno-Maldonado and Santamaria, 2024). As the causes of gentrification are not the focus of our study, we remain agnostic about the deep roots of urban gentrification. We instead generate gentrification through exogenous growth of center city amenities, which will interact with income-dependent preferences and the housing market to push low-income households to

the periphery.

Second, our paper contributes to the literature studying neighborhood composition and neighborhood change. Our model builds explicitly on the quantitative spatial equilibrium tradition recently synthesized by [Redding \(2025\)](#), extending it by incorporating spatial spillovers and a lottery-based public housing allocation mechanism. Within this literature, our work is primarily related to two branches. The first is the branch studying spatial inequality ([Kline and Moretti, 2014](#); [Diamond, 2016](#); [Couture and Handbury, 2020](#)) and spatial sorting on socioeconomic characteristics ([Diamond, 2016](#); [Almagro and Domínguez-Iino, 2025](#); [Bayer and Timmins, 2007](#); [Kuminoff et al., 2013](#); [Eeckhout et al., 2014](#); [Diamond and Gaubert, 2022](#); [Behrens et al., 2014](#)). The second branch we build on studies the effects of housing policy on urban structure ([Ahlfeldt et al., 2015](#); [Diamond and McQuade, 2019](#); [Heblich et al., 2020](#); [Almagro et al., 2023](#); [Redding and Sturm, 2024](#)).

Third, this paper also contributes to a literature on the relationship between neighborhood businesses and neighborhood composition. [Couture and Handbury \(2020\)](#) and [Baum-Snow and Hartley \(2020\)](#) argue that changing tastes for services over the last couple of decades are important drivers of the observed movement into neighborhoods that provide those amenities. [Schiff \(2014\)](#) and [Davis et al. \(2019\)](#) show how the variety and density of restaurants correlates with neighborhood composition. [Glaeser et al. \(2018\)](#) and [Behrens et al. \(2024\)](#) identify several categories of local services that predict gentrification. Finally, we build closely on the literature which endogenizes the provision of services and household sorting in general equilibrium ([Almagro and Domínguez-Iino, 2025](#); [Couture and Handbury, 2020](#)). We employ a similar setting to these papers, but add spatial spillovers, which allows us to model locations at a fine level.

Fourth, at a broad level, our paper contributes to the study of mixed public-private markets, where public providers compete with the private sector. Early theoretical work shows that inserting a public firm into an oligopoly fundamentally reshapes equilibrium prices, output and welfare ([De Fraja and Delbono, 1989](#); [Cremer et al., 1989](#)). Mixed provision is present in education through competition between public school districts and private alternatives, which has been shown to increase productivity and test scores ([Hoxby, 2000](#)), and in health insurance, where the introduction of public or publicly subsidized plans alters enrollment, pricing and welfare in private coverage ([Einav et al., 2013](#); [Mahoney, 2015](#)). Together these studies underscore the common insight that when access to a publicly provided good is governed by non-price allocation rules, it disciplines private-sector prices and reshapes who participates and where. Our paper extends this literature by investigating the effect of the public option in urban housing markets. In particular, we extend the traditional discrete choice framework of [McFadden \(1974\)](#) for housing market equilibrium modeling by achieving total market clearing through access lotteries in the public housing sector.

This paper contributes to the emerging literature on gentrification in several ways. First, by exploiting a large-scale natural experiment – the privatization of public housing – we are able to disentangle the effects of neighborhood composition from the effects of changes in the provision of local urban amenities. Second, we provide an empirical assessment of the consequences of public housing privatization and evaluate its significance for the supply of local amenities. Third, our quantitative model enables us to examine the interaction between public housing and urban gentrification, highlighting the role of rent-regulated housing in shaping the geography and pace of gentrification, housing affordability, and neighborhood

composition.

The paper proceeds as follows. Section 2 presents the data and the stylized facts. Section 3 outlines the dynamic quantitative spatial model with a mixed housing system and endogenous consumption amenities. Section 4 discusses the identification strategy, estimation, and resulting parameter estimates. Section 5 presents counterfactual exercises based on the estimated model to assess how changes in public housing shape city structure, with a particular emphasis on gentrification dynamics and residents’ welfare. Finally, Section 6 provides concluding remarks.

2 Data and Stylized Facts

2.1 Data

Our data consists of an individual-level panel dataset of all residents in the Copenhagen Metropolitan Area (CMA), as defined in [Ahlfeldt et al. \(2025\)](#), covering the period 1986–2016, see Figure 1.³ For each individual, we observe the residential location at a spatial resolution of 100-by-100-meter grid cells, the type and price of the residential property, and detailed demographic characteristics, including age, educational attainment, family type, number of children, and income. The hectare cells can be aggregated to larger geographical units, including four-hectare (200-by-200-meter) cells, parishes, and municipalities.⁴

We restrict the dataset to individuals aged 18 years or older. The sample comprises more than 2.7 million unique individuals and over 43 million person-year observations. We sometimes refer to the core of the CMA – the municipalities of Copenhagen and Frederiksberg – yielding more than 15 million observations representing approximately 1.5 million unique individuals. We observe the universe of residential units in the CMA in each year and can link each unit to its occupants. The data on residential units include information on tenure type. We also use these data to identify privatized public housing units. In our sample, the mean annual residential relocation rate is approximately 19%. Moreover, the probability that an individual transitions from public housing to the private market is 6.7%, while the corresponding probability of moving from the private market into public housing is 2.2%.

Table 1 presents descriptive statistics for individuals in the CMA, split between the core and suburban areas. Overall, the population is middle-aged (average is about 47 years) with a roughly even gender distribution. Clear spatial differences emerge. Residents in the core are younger, have lower incomes, smaller households, and fewer children, while suburban residents are older, wealthier, and more likely to live in larger family units. Housing conditions also differ, with more floor space per adult in suburban areas. The core has a higher share of highly educated individuals, whereas suburban areas have relatively more medium- and low-educated residents. Finally, public housing is more prevalent in suburban areas. These patterns are consistent with urban sorting.

³The definition of the CMA in [Ahlfeldt et al. \(2025\)](#) is based on commuting flows and thus reflects integrated local labor and housing markets. The resulting CMA encompasses 3,038 square kilometers, and 92% of individuals employed within this area also reside there.

⁴For confidentiality reasons, precise coordinates are not disclosed. Instead, locations are reported at the 100-by-100-meter (one-hectare) grid-cell level.

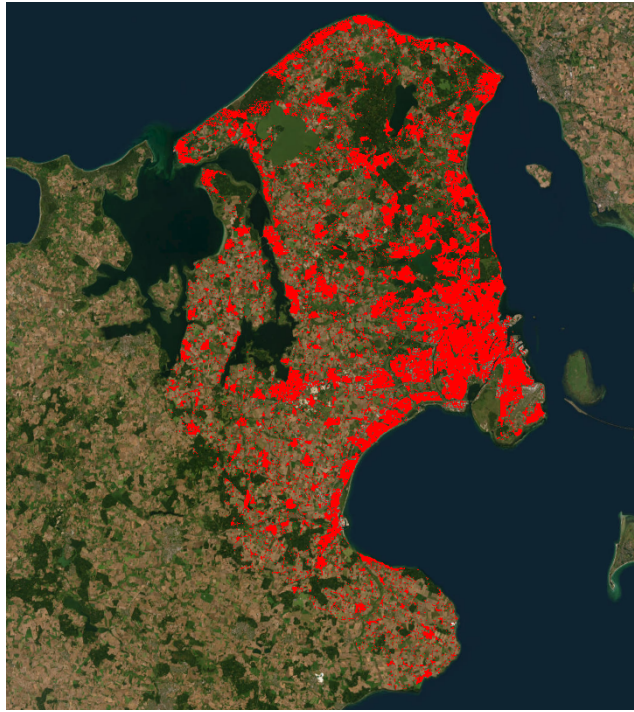


Figure 1: Copenhagen Metropolitan Area (CMA)

Notes: The red colored areas are populated cells within the CMA.

Table 1: Sample descriptives by residential location

	Total	Core area	Suburban area
Age, years	46.540 (18.150)	43.957 (18.944)	47.907 (17.562)
Female, share	0.520 (0.500)	0.525 (0.499)	0.518 (0.500)
Annual income (1,000 DKK)	166.783 (229.985)	146.553 (197.114)	177.483 (244.923)
Household size (number of persons)	2.898 (9.424)	2.804 (14.521)	2.948 (4.923)
Number of children in household	1.148 (1.167)	0.791 (1.094)	1.338 (1.159)
Floor space per adult (m ²)	59.478 (26.032)	53.085 (24.776)	62.964 (26.038)
Low education, share	0.250 (0.433)	0.222 (0.415)	0.266 (0.442)
Medium education, share	0.518 (0.500)	0.462 (0.499)	0.548 (0.498)
High education, share	0.096 (0.295)	0.131 (0.337)	0.078 (0.268)
Public housing, share	0.231 (0.422)	0.198 (0.398)	0.249 (0.432)
Number of observations	43,574,560	14,978,672	28,595,888

Signs of gentrification dynamics are evident in Figures 2 and 3. First, Figure 2 shows that the share of highly educated residents increases over time in both the core and suburban areas, but substantially more in the core, resulting in a widening gap. In the initial period, the shares are relatively low and similar across locations. However, over time the core diverges markedly, such that by 2016 it exhibits a significantly higher concentration of highly educated individuals. This pattern reflects a pronounced increase in human capital across the metropolitan area, with a particularly strong acceleration in central locations.

The divergence between the core and the suburbs is indicative of intensified skill sorting, whereby highly educated, and by implication higher-income households, increasingly concentrate in central areas. This process is a defining feature of gentrification (Hwang and Lin, 2016). While suburban areas also experience improvements in educational attainment, the comparatively slower pace suggests that they are less directly exposed to these upgrading dynamics.

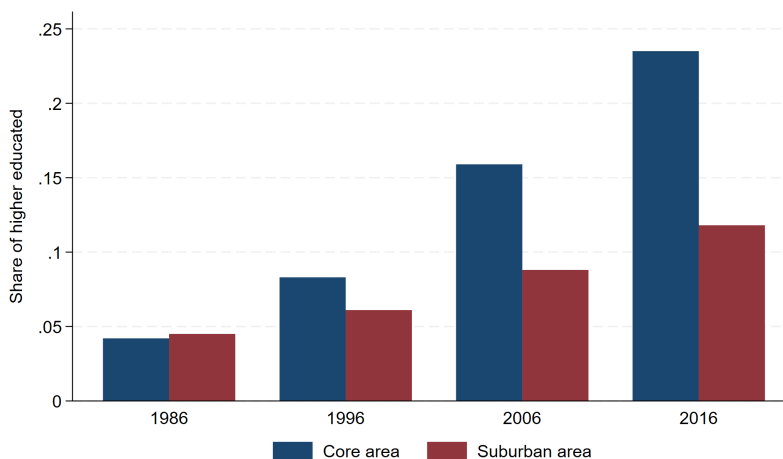


Figure 2: Share of higher-educated population by area and year

Notes: High education includes bachelor, long-cycle higher education and PhD-degree.

Second, we construct parish-level house price indices for the period 1986–2016 using Danish administrative register data on real estate transactions. These data include detailed structural dwelling characteristics from the Building and Dwelling Register (BBR), such as unit size, number of rooms, housing type (e.g., single-family or multifamily), and building age. Because transaction data are spatially sparse, we follow Ahlfeldt et al. (2023) and apply their methodology to estimate house price indices for arbitrary spatial units based on repeated cross-sections of geocoded microdata. Transaction-level price information is available for the period 1993–2016. For the earlier period, 1986–1992, we impute neighborhood-level price indices by combining the evolution of dwelling-level property assessments with the estimated price levels in 1993.⁵

Figure 3 documents a substantial and spatially pervasive increase in housing prices over time,

⁵For parts of the reduced-form analysis, we additionally use house price indices at the 200-by-200-meter level from Ahlfeldt et al. (2025), which are constructed using the universe of real estate transactions in Denmark combined with detailed property characteristics, following the methodology of Ahlfeldt et al. (2023).

with especially pronounced growth in the core area.⁶ Comparing 1992 to 2015, the distribution of housing prices becomes both higher on average and more spatially compressed, reflecting a general upward shift in the price level across locations. This pattern is consistent with increased demand for central locations, likely driven by the inflow of high-income and more educated residents, which in turn exerts upward pressure on housing prices. Taken together, the two figures highlight the central mechanisms underlying gentrification: the reallocation of high-skill households toward the urban core and the associated increase in housing prices.

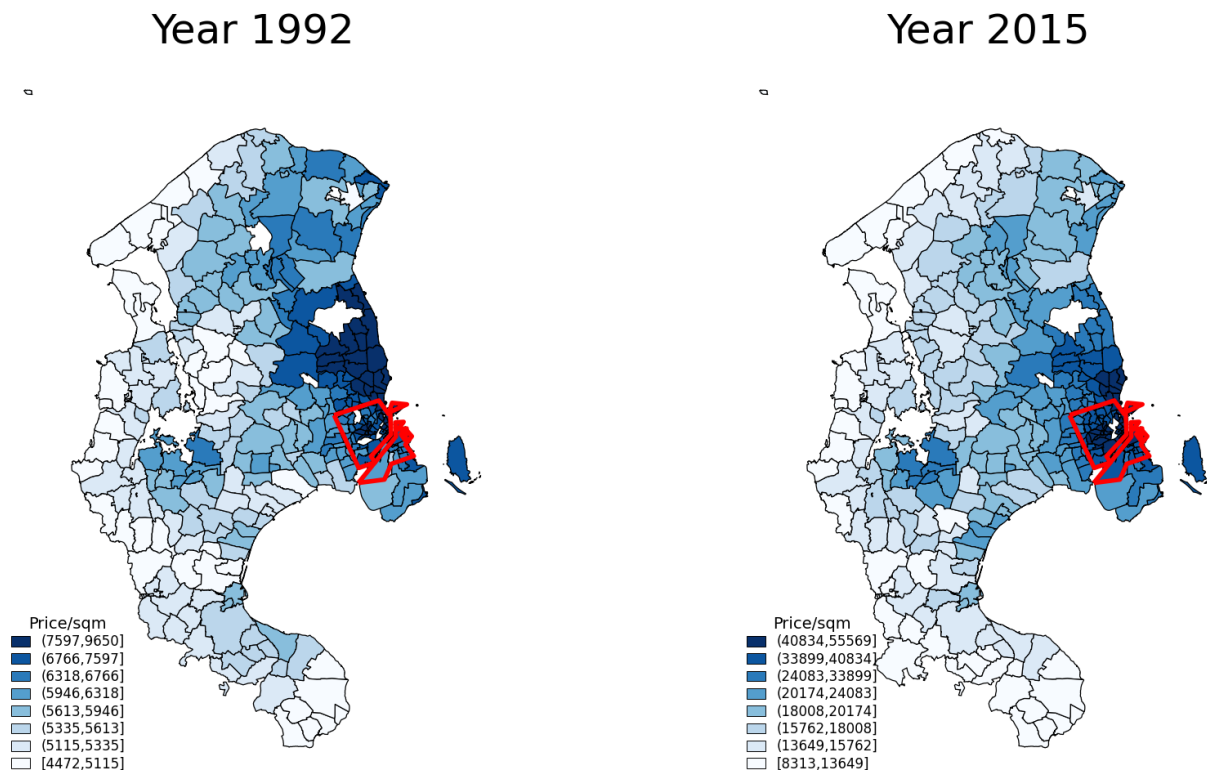


Figure 3: HPI (DKK/sqm) by parish for years 1992 and 2015

Our dataset also includes annual information on business locations at the hectare level from 1992-2014, enabling us to identify local consumption amenities and public services, such as supermarkets, restaurants, greengrocers, general practitioners, and schools, at a high level of spatial precision of 100-by-100-meter grid cells. Finally, we use walking times (measured in minutes) for the year 2015 between all 200-by-200-meter cells in the CMA. These travel-time measures are used to construct accessibility indices and to analyze potential spatial spillover effects.⁷

⁶Figure B.1 in Appendix B replicates the maps using identical quantiles of the house price index (HPI) for scaling.

⁷To reduce computational complexity, Ahlfeldt et al. (2025) aggregate 100-by-100-meter cells to 200-by-200-meter cells. In total, 30,150 such cells in the CMA have at least one resident or worker during the sample period. Ahlfeldt et al. (2025) compute 2015 walking-time distances (in minutes) for all approximately 909 million bilateral cell pairs.

2.2 Privatization of Public Housing Owned by the City of Copenhagen

Copenhagen’s housing stock consists of several major tenure types: private housing (owner-occupied or privately rented, 42%), cooperative housing (28%), and public housing (20%). Privately owned housing is subject to the least regulation, while private rental housing is partially regulated through rent control, particularly for units constructed before 1992 ([Københavns Kommune, 2024](#)). Cooperative housing constitutes a distinct form of private ownership in which a resident-controlled association owns the building, and individual members own a share of the association’s equity along with the exclusive right to occupy a specific unit. Although cooperative units are generally less expensive than non-cooperative private units, their prices largely follow the dynamics of the private market, as most associations base maximum sales prices on market-value appraisals. In practice, access to cooperative housing is governed by paid waiting lists or priority arrangements through social networks ([Københavns Kommune, 2024](#)).

Public housing primarily consists of government-subsidized, non-profit cooperative housing operated by local housing associations, historically supplemented by municipally-owned public units. Housing associations receive government subsidies for new construction and are required to set cost-based rents. In principle, access to public housing is universal, although roughly one-fourth of vacancies are reserved for municipalities, which allocate these units to households with special needs.⁸ Otherwise, public housing is allocated via waiting lists, typically with modest annual fees. Public housing is relatively evenly distributed across Copenhagen, with the exception of the historical city center, which is more heavily dominated by commercial activity.⁹

In the early 1990s, the Municipality of Copenhagen faced a substantial and persistent budget deficit.¹⁰ At the time, the city had a disproportionately large share of pensioners, unemployed individuals, single-person households, and socially vulnerable residents relative to other Danish municipalities. This demographic composition placed considerable pressure on municipal expenditures, while tax revenues grew more slowly than in the rest of Denmark.

In 1996, the Municipality of Copenhagen unexpectedly decided to divest of its entire stock of publicly owned rental housing, comprising more than 19,000 units in 235 properties ([Rasmussen, 2002](#)). The sale formed part of a broader financial agreement between the municipality and the central government. Its immediate purpose was to prevent the municipality from being placed under state administration. In the longer run, the divestiture aimed to restore fiscal sustainability. The rental stock represented approximately 8% of the municipality’s total housing supply and accounted for a sizeable share of public housing (22%) as well. Tenants were granted the opportunity to purchase their dwellings, and by 2001 the majority of units had been sold to incumbent residents who converted the properties into cooperatives.

⁸There are also types of public housing that specifically target students or the elderly.

⁹The supply of public housing has tended not to vary much from year to year, with the percentage of individuals living in public housing increasing slowly from around 17% in 1986 to 23% in 1995 and this figure holding steady at around 18-19% from 1996 onward. The smooth trend in the share of people in public housing is broken by an extensive privatization event in 1995-1996.

¹⁰The municipality’s budget deficit amounted to DKK 2.9 billion (EUR 363 million) in its 1995 budget proposal.

Resident demand for cooperative ownership were substantial. By 2000, out of roughly 19,000 dwellings, 16,500 had been sold as cooperatives, 600 to non-profit housing associations, and 1,400 to private landlords. The remaining 500 units took longer to sell due to their small size, relatively unattractive locations, limited development potential, or high prices resulting from previous urban renewal initiatives. The policy thus played a central role in altering the composition of the city’s housing stock and contributed materially to preventing municipal insolvency. Moreover, the initiative was explicitly designed to attract and retain residents with higher taxable incomes, although no direct causal link between demographic changes and the sale of municipal dwellings has been formally established.

The divestiture generated an unexpected and substantial reduction in the supply of public housing in Copenhagen. We exploit this quasi-experimental shift in the availability of rent-controlled units to estimate our model and examine the effects of regulated rental housing on patterns of gentrification. Appendix A2 provides a detailed account of the privatization of municipally owned public housing.

2.3 Public Housing and City Structure

2.3.1 Public Housing, Neighborhood Composition, and Housing Prices

We begin by exploring whether and how rapidly neighborhood-level outcomes adjust following the privatization of public housing. Specifically, we investigate whether the privatization induced changes in neighborhood composition and local housing prices. We treat the privatization of public housing as an exogenous event and estimate the dynamic effects of public housing privatization using an event-study specification:

$$\ln y_{lt} = \sum_{\tau \neq -1} \beta_{\tau} \cdot \mathbb{1}[t - T_l = \tau] + \lambda_l + \delta_t + \varepsilon_{lt}. \quad (1)$$

Here, y_{lt} denotes the outcome of interest in neighborhood l at time t , and T_l is the year in which neighborhood l is first exposed to privatization. The indicator $\mathbb{1}[t - T_l = \tau]$ captures event time τ , defined relative to the year of treatment, with $\tau = -1$ omitted as the reference period. The coefficients β_{τ} trace out the evolution of outcomes before and after privatization. The specification includes neighborhood fixed effects λ_l and year fixed effects, δ_t , to account for common shocks. ε_{lt} is an idiosyncratic error term.

We estimate the effects of public housing privatization using the event-study methodology of [Borusyak et al. \(2024\)](#). This approach is based on a counterfactual estimator that separates the estimation of treatment effects from the estimation of neighborhood fixed effects. By construction, it avoids the issues of forbidden comparisons and negative weighting that can arise in conventional two-way fixed effects estimators ([Callaway and Sant’Anna, 2021](#); [Sun and Abraham, 2021](#)). In this specification, we restrict the sample to neighborhoods located within 10 km of the city center in order to exclude suburban areas from the control group.

We plot the estimated coefficients β_{τ} from Equation (1) in Figure 4. First, consistent with a large body of evidence showing that housing prices capitalize neighborhood composition and quality, we find that the privatization reform had a positive effect on local housing prices (upper-left panel). The effect builds gradually over time and continues to increase for at least a decade after the reform, in line with the slow adjustment dynamics typical of residential

sorting. The magnitude is economically significant. Ten years after the treatment, the average effect amounts to approximately 17%, i.e., $\exp(0.152) - 1$ (see Table 2).

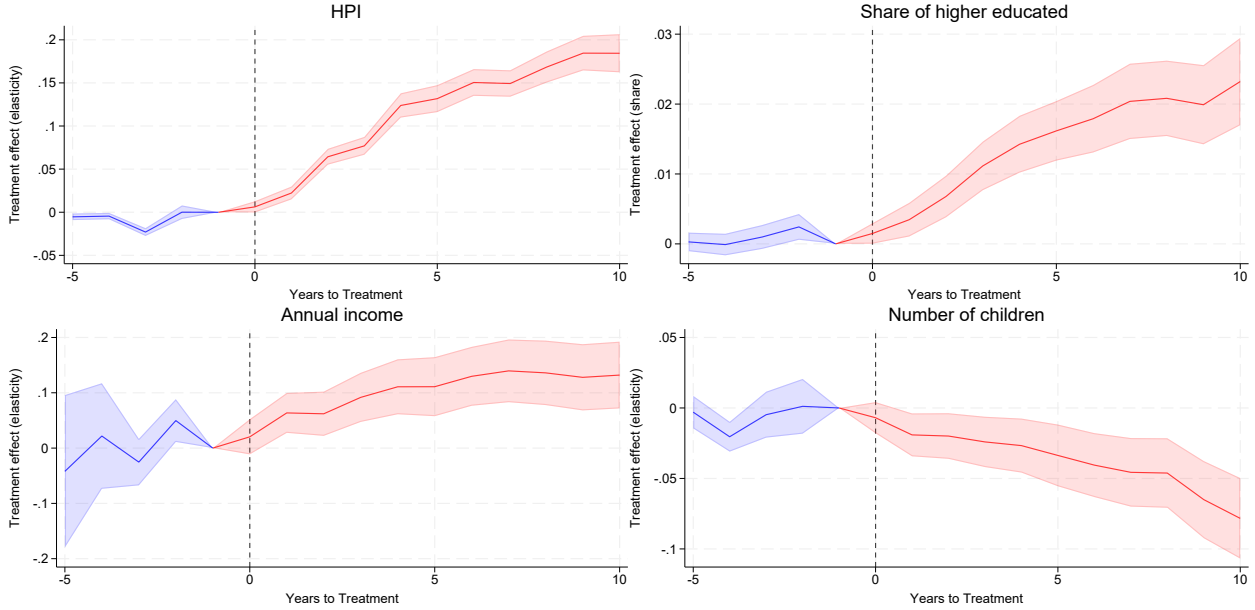


Figure 4: Impact of Public Housing Privatization

Notes: Each panel illustrates the impact of public housing privatization defined in Eq. (1).

The results further indicate that privatization led to a relative increase in the share of highly educated residents in treated neighborhoods compared with untreated ones (upper-right panel). We also observe a corresponding increase in disposable income (lower-left panel), reflecting the inflow of higher-income households. Finally, the estimates point to a decline in the number of children (lower-right panel).

Overall, the adjustments occur gradually, with neighborhood characteristics continuing to evolve for several years following the reform, indicating that the full effects of privatization materialize only in the medium to long run.¹¹

The impact of privatization on neighborhood composition is also substantial and economically meaningful, see Table 2. The results indicate that the share of higher-educated residents had increased by 2.5 percentage points, the number of children had declined by 6% ($\exp(-0.062) - 1$), and average income had risen by 12% ($\exp(0.114) - 1$) in treated neighborhoods relative to the control group.¹²

¹¹Figure B.2 in Appendix B presents additional event-study results. These estimates show a significant decline in the share of lower-educated residents in treated neighborhoods. Moreover, although the border-line significant pre-trend warrants some caution, the reform appears to have halted the growth in the share of non-Western immigrants in treated neighborhoods.

¹²We additionally estimate the same models using different radii (<5 km and <20 km). The results remain robust across these alternative specifications. Finally, we estimate specifications analogous to Equation (1) in which the treatment indicator is interacted with the share of public housing privatized in each neighborhood. The estimated coefficients are shown in Figure B.3 in Appendix B. The results remain robust to this alternative specification.

Table 2: Impact of Public Housing Privatization for Neighborhoods Located within 10 km of the city center, post treatment average

	(1)	(2)	(3)	(4)
	log HPI	Share of high educated	log income	log number of children
Treatment (privatization)	0.152*** (0.009)	0.025*** (0.002)	0.114*** (0.034)	-0.062*** (0.012)
Neighborhood FEs, λ_l	yes	yes	yes	yes
Year FEs	yes	yes	yes	yes
R-squared	0.836	0.817	0.941	0.974
Observations	19,167	19,167	19,167	19,167

Notes: Treatment is a binary variable equal to one if at least one public housing property in neighborhood l was privatized. λ_l are neighborhood fixed effects, and δ_t are year fixed effects. The treatment coefficient capture the treatment effects comparing treated and untreated neighborhoods relative to the year of treatment. Std. errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

2.3.2 Public Housing and Consumption Amenities

To analyse the impact of privatization on local consumption amenities, we rely on an accessibility measure. The accessibility index we use captures the proximity of a given location to all other locations and has its roots in the literature on agglomeration economies (Rosenthal and Strange, 2001, 2004; Lucas and Rossi-Hansberg, 2002; Melo et al., 2009; Redding and Rossi-Hansberg, 2017). Redding (2025) uses a closely related measure as a standard indicator of residential and workplace commuting market access. H. Hanson (2005) similarly applies this index to capture locations' proximity to consumer markets. We follow this general approach, but we weight connections by walking travel time. The value of the public housing proximity of neighborhood l at time t , $Prox_l(t, \xi_s)$, is:

$$Prox_l(t, \xi_s) = \sum_{l' \in L} \omega_{l'}(t) \exp(-\xi_s d_{ll'})$$

where $\omega_{l'}$ is the share of public housing in overall floor space in neighborhood l' , ξ_s is the spatial decay parameter, and $d_{ll'}$ is the walking travel time between neighborhoods l and l' .

We identify the effect of public housing on locally provided consumption amenities (business types) through changes in public-housing accessibility across Copenhagen that are induced by the privatization of public housing. We regress the log number of firms in business sector s in neighborhood l at time t , $m_{sl}(t)$, on the public housing proximity of neighborhood l :

$$\ln(m_{sl}(t)) = \gamma_{s,\omega} \ln(Prox_l(t, \xi_s)) + \gamma_{sl} + \gamma_{st} + \eta_l(t) \quad (2)$$

where γ_{sl} is the sector specific neighborhood fixed effect, γ_{st} is the sector specific year fixed effect, and $\eta_{sl}(t)$ is an i.i.d. error term. Since we have panel data for neighborhoods, we can control for all differences in amenities that remain constant over time using neighborhood-fixed effects. This allows us to deal in a general way with the concern that the level of consumption amenities may be correlated with the level of public housing, for instance because more central neighborhoods tend to have less public housing than those in suburban areas. We also estimate a sector specific distance decay parameter ξ_s . By treating ξ_s as one of the parameters to be

estimated we allow the scope of the effect of public housing on local business sectors to be determined by the data.¹³

There are several issues that deserve further discussion when estimating the relationship between public housing and local amenities as given by (2). First, a typical concern in studies analyzing the location of public housing is that these are often constructed in response to existing neighborhood characteristics, raising concerns about endogeneity. Moreover, given the way we constructed our measure, it also depends on the complete distribution of the evolution of local public housing. Suppose for example that the more public housing was constructed in response to an expected change in neighborhood characteristics, then this might lead to reverse causality. However, because legislation requires that the share of public housing within each municipality be at least 20%, and because the construction of new public housing is constrained by land availability, public-housing units are relatively evenly distributed across Copenhagen. They are therefore not constructed in response to anticipated changes in neighbourhood characteristics. More importantly, our identification strategy relies on a natural experiment – the unexpected privatization of public housing – which substantially reduces concerns about potential endogeneity in our setting.

Table 3 presents the estimation results. The main takeaway is that an increase in public-housing accessibility has a positive effect on the number of supermarkets, greengrocers, and kiosks, and a negative effect on the number of restaurants, general practitioners, primary schools and non-consumption amenities. All estimated elasticities are economically meaningful and precisely measured. For example, a 1% increase in accessibility to public housing raises the number of supermarkets by 0.17% and reduces the number of restaurants by 0.19%. The only exception is the elasticity for primary schools, which, although precisely estimated, is economically negligible (< 0.01).

Furthermore, we find that the impact of public-housing proximity on greengrocers and kiosks, as well as on primary schools, is much more localized relative to its impact on the other consumption amenities considered. While the effect on greengrocers and kiosks declines by 50% within just 2 km and becomes negligible beyond 10 km (with a decay parameter of $\xi = 0.30$), the effect on supermarkets remains at 90% of its initial magnitude at 2 km and only falls to around 50% at approximately 25 km (with $\xi = 0.03$).¹⁴

2.4 Summary of Stylized Facts

Section 2.1 highlights the central mechanisms underlying gentrification, namely the reallocation of high-skill households toward the urban core and the concomitant increase in housing prices. Sections 2.3.1 and 2.3.2 document the role of public housing in shaping gentrification dynamics through four empirical facts. First, a reduction in public housing provision led to a gradual increase in the share of highly educated residents and in average disposable income. Second, this contraction in the public-housing stock generated upward pressure on local housing prices. Third, changes in accessibility to public housing affected the provision of consumption amenities. Increases in public-housing accessibility induced by privatization

¹³We apply a grid-search over different values of ξ_s for the model (2). The objective is to identify the decay parameter ξ_s that maximizes R^2 .

¹⁴Figure B.4 in Appendix B shows how the weights in the accessibility measure vary with different values of the decay parameter.

Table 3: Consumption Amenities and Accessibility to Public Housing

	(1)	(2)	(3)	(4)	(5)	(6)
	Supermarkets	Restaurant	GP	Primary schools	Greengrocers and kiosks	Non-cons. amenities
log of public housing proximity, $Prox_l$	0.170*** (0.011)	-0.163*** (0.007)	-0.191*** (0.016)	-0.006*** (0.002)	0.011*** (0.002)	-0.283*** (0.024)
Decay, ξ	0.03	0.10	0.03	0.16	0.30	0.12
Neighborhood FE, γ_l	yes	yes	yes	yes	yes	yes
Year FE, γ_t	yes	yes	yes	yes	yes	yes
Constant	-1.473*** (0.095)	1.156*** (0.050)	1.684*** (0.136)	0.051*** (0.010)	-0.035*** (0.009)	2.439*** (0.009)
R-squared	0.849	0.768	0.868	0.938	0.663	0.853
Observations	367,755	367,755	367,755	367,755	367,755	367,755

Notes: The table shows the estimates for the effect of the log of the public housing proximity of neighborhood l on the log number of firms in business sector (consumption amenities) for specification (2). Std. errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. See Figure B.4 in Appendix B to see how the weight changes with distances for the above decays.

raised the number of supermarkets, and greengrocers, while reducing the number of restaurants, general practitioners, and primary schools. Taken together, these findings indicate that adjustments to the stock of rent-controlled public housing have substantial effects on neighborhood sorting, local housing prices, and the composition of consumption amenities.

3 Theoretical Framework

In this section we present a dynamic model of a mixed housing market with movement costs, uneven random access to public housing in each location, and sectoral spatial spillovers. Assign each individual i to a group, where each group is defined by some characteristics, with the set of groups being K . Let L be the set of neighborhoods and let Ω be the set of housing types (e.g., private or public housing). Define the set of residential choices $J = L \times \Omega$, such that each $j \in J$ corresponds to a pair (l, ω) , where $l \in L$ and $\omega \in \Omega$.

3.1 Deterministic Flow Utility

The deterministic component of flow utility for any individual in group k residing in j is given by:

$$u_j(k, t) = A_j(t)C_l(k, t)^{\phi(k)}H_j(k, t)^{1-\phi(k)}, \quad \phi(k) \in [0, 1]$$

Here $A_j(k, t)$ is the value of amenities in pair j . H_j is the amount of housing services consumed and C_l aggregates consumption such as restaurant spending, groceries, etc. ϕ describes the relative preference for non-housing expenditure. Assume that deterministic utility is the same for all individuals i within each group k . Let $U_j(k, t)$ denote the indirect deterministic flow utility:

$$U_j(k, t) = A_j(t)y(k, t)P_l(k, t)^{-\phi(k)}r_j(t)^{\phi(k)-1} \quad (3)$$

Here $y(k, t)$ is exogenous income which is independent of the residential choice, $P_l(k, t)$ is the non-housing consumption price index in location l , and $r_j(t)$ is the price of housing in

residential choice j . The price of housing is the same for all groups, while the price index can differ across types, as the underlying preferences for different consumption goods may be different between groups.

3.2 Dynamics of Residential Choice

Individuals pay an iceberg movement cost $\tau_{jj'}(k, t) = \tau(k) \ln d_{jj'}$, where $d_{jj'}$ is the travel time between residential choices. At $t - 1$, each individual i draws a random utility shock for each j at t , $\epsilon_j(t)$. These shocks are drawn independently from a Gumbel distribution with unit shape parameter.

Let $V_j(k, t)$ be the value to an individual in group $k \in K$ of residing in j at time t , net of movement costs and the idiosyncratic shock. When moving from j' to j at time t , this individual receives $V_j(k, t) - \tau_{j'j}(k, t) + \epsilon_j(t)$. Denoting the individual's stochastic choice set by $\mathcal{J}_i(t + 1)$, the individual's Bellman equation satisfies:

$$V_j(k, t) = U_j(k, t) + \rho \mathbb{E} \left[\max_{j' \in \mathcal{J}_i(t+1)} \{V_{j'}(k, t+1) - \tau_{jj'}(k, t+1) + \epsilon_{j'}(t+1)\} \right] \quad (4)$$

3.2.1 Rationing of Public Housing

Public housing differs from private housing in that rents do not adjust to clear the market. Let $\omega = 0$ denote private housing and $\omega = 1$ denote public housing. For each location l , the public housing rent, $r_{(l,1)}(t)$, is treated as an administratively determined cost rent. At this rent, desired demand generally exceeds the available stock. The allocation of public housing is therefore governed by non-price rationing.

We treat rationing as a waiting-list and priority-allocation mechanism. This is intended to be consistent with four institutional features of the Danish system: ordinary external waiting lists, internal waiting lists for current public-housing tenants, municipal assignment of units to households with urgent housing needs, and local flexible letting criteria. The model does not require us to observe individual waiting-list positions. Instead, waiting-list priority is summarized by an offer probability that depends on household type, origin housing type, and location. Let $\mathbb{P}(j'|j, k, t)$ be the probability that a group- k individual that resided in j at time $t - 1$ gains access to public housing in j' at time t through any of the channels.

3.2.2 Transition Probabilities

Generically, each individual will have access to a subset of the housing in each period. Hence, the choice set is itself individual-specific. In this case, the probability that any individual i from group k who resides in j moves to j' at time t is given by:

$$\mu_{jj'}(k, t) = \sum_{J' \in \mathcal{P}(J)} \mathbb{P}(J'|j, k, t) \frac{\mathbb{1}\{j' \in J'\} \exp(V_{j'}(k, t) - \tau(k)d_{jj'})}{\sum_{j'' \in J'} \exp(V_{j''}(k, t) - \tau(k)d_{jj''})}$$

Here $\mathcal{P}(J)$ denotes the power set of J and $\mathbb{P}(J'|j, k, t)$ is the probability that an individual i from group k residing in j has access to the choice set $J' \subseteq J$ at time t .

This power set is generically very large, and the researcher does not typically observe an individual's choice set. We therefore work with a tractable reduced form of this problem. Intuitively, if a household-type is less likely to get access to public housing, the econometrician will be less likely to observe them moving into public housing. There is a utility shifter equivalent, $\alpha_{jj'}(k, t)$, that rationalizes the transition probabilities, $\mu_{jj'}(k, t)$, of all types of individuals under rationing in the public housing sector:¹⁵

$$\mu_{jj'}(k, t) = \frac{\exp(V_{j'}(k, t) - \tau_{jj'}(k, t) - \alpha_{jj'}(k, t))}{\sum_{j'' \in J} \exp(V_{j''}(k, t) - \tau_{jj''}(k, t) - \alpha_{jj''}(k, t))} \quad (6)$$

We impose three core assumptions on the utility shifter equivalents, $\alpha_{jj'}(k, t)$. Firstly, it is always possible for households to stay where they are:

$$\alpha_{jj}(k, t) = 0$$

Secondly, it is always possible to move into private housing:

$$j' = (l, 0) \Rightarrow \alpha_{jj'}(k, t) = 0$$

Thirdly, the utility shifter depends on the source housing type ω , not the source residential choice j :¹⁶

$$\alpha_{jj'}(k, t) = \alpha_{\omega j'}(k, t)$$

The utility shifter equivalents are group specific, which describes the different priorities given to different groups.

3.2.3 Migration into the City

Let the value of living outside of the city be $V_{out,t}$. To move into the city, individuals must pay a type-specific moving cost $\chi(k, t)$ before they draw their idiosyncratic preference shock $\epsilon_j(i, t)$. The entry indifference condition is that the expected value of moving into the city must be equal to the value of remaining outside:¹⁷

$$V_{out,t} = \gamma + \ln \left(\sum_{j \in J} \exp(V_j(k, t) - \alpha_{out,j}(k, t)) \right) - \chi(k, t) \quad (7)$$

¹⁵In the special case that there is only a negligible probability that an individual has access to public housing in more than one location in any period, the following approximation holds (see Appendix C1.2):

$$\mathbb{P}(j'|j, k, t) \approx \exp(-\alpha_{jj'}(k, t)) \quad (5)$$

¹⁶This reflects the Danish system in which public housing is allocated differently for those already living in public housing and those living in private housing.

¹⁷ γ is the Euler-Mascheroni constant.

3.3 Housing Market Clearing

In our baseline model, we will assume that the total available floor space, $\mathcal{L}_l(t)$, and the total floor space of private and public housing respectively, $\mathcal{H}_{(l,0)}(t)$ and $\mathcal{H}_{(l,1)}(t)$, are exogenously given under the following binding constraint.

$$\mathcal{L}_l(t) = \mathcal{H}_{(l,0)}(t) + \mathcal{H}_{(l,1)}(t) \quad (8)$$

Let $\mathcal{I}_j(k, t)$ be the number people in the residential choice j from each group. No exclusively price-driven market clearing condition can be imposed on the market for public housing. Instead, the option to move to public housing is given to individuals in different groups receiving different levels of priority. We will assume that both the private and public housing markets clear through the following relationship:¹⁸

$$\mathcal{H}_j(t) = \sum_{k \in K} \mathcal{I}_j(k, t) \frac{(1 - \phi(k))y(k, t)}{r_j(t)}. \quad (9)$$

The total mixed housing market clears through the housing prices, $r_j(t)$, and the utility shifter equivalents, $\alpha_{jj'}(k, t)$, that describe the access to housing types for different groups.

Since housing prices are fixed in the public housing sector and all $\alpha_{jj'}(k, t) \geq 0$, it is theoretically possible that the public housing sector will not clear through any allowed utility shifter equivalents. Therefore we assume that the public housing prices are fixed unless all $\alpha_{jj'}(k, t) = 0$ for some j' , in which case the local housing market in j' clears through the public housing price, reflecting the notion that owners of public housing will generally rather accept a lower price than leave it vacant.

3.4 Consumption Amenities

Households have Cobb–Douglas preferences across sectors S and, within each sector, constant-elasticity-of-substitution (CES) tastes over goods differentiated by the location of production. Let $c_{sl'}(n, k, t)$ be the quantity of a sector- s good of variety n produced in l' and consumed in l by a group k individual at time t . The within-sector aggregator is:

$$C_{sl}(k, t) = \left[\sum_{l' \in L} \sum_{n \in N_{sl'}(t)} c_{sl'}(n, k, t)^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}} \quad (10)$$

Overall composite consumption is:

$$C_l(k, t) = \prod_{s \in S} C_{sl}(k, t)^{\beta_s(k)} \quad (11)$$

Each individual chooses a consumption bundle to maximize utility under the budget constraint. Assume each firm posts a single price, $p_{sl}(n, t)$, and individuals face a sector-specific iceberg trade cost $\delta_{sl'}(t) \geq 1$.

¹⁸Public housing does not require paying a market-based rent, but it is not free. Residents must still pay for the cost of maintaining the apartment building.

3.4.1 Individual Optimization

Consumers face local prices $\{\delta_{sl'}p_{sl'}\}_{l' \in L}$. Demand is given by:

$$c_{sl'}^*(n, k, t) = y_s(k, t) \frac{(\delta_{sl'}p_{sl'})^{-\sigma_s}}{P_{sl}(t)^{\sigma_s-1}}, \quad (12)$$

$$y_s(k, t) \equiv \phi(k)\beta_s(k)y(k, t), \quad P_{sl}(t) \equiv \left[\sum_{l' \in L} \sum_{n \in N_{sl'}(t)} (\delta_{sl'}p_{sl'})^{1-\sigma_s} \right]^{\frac{1}{1-\sigma_s}}$$

Assume that the trade cost is an increasing function of the travel time, $d_{ll'}$. We will assume the following functional form:

$$\delta_{sl'} = \exp(\xi_s d_{ll'}) \quad (13)$$

This specification ensures that $\delta_{sl'} \geq 1$ for any $\xi_s \geq 0$, since $d_{ll'} \geq 0$.

3.4.2 Technology and Pricing

Assume that each firm faces a marginal cost c_s that is the same for all firms within a sector. Plugging the demand expression into the firms' profit function and solving for the optimal factory-door price, we get the standard markup rule:

$$p_{sl'}^* = \frac{\sigma_s}{\sigma_s - 1} c_s \equiv p_s^* \quad (14)$$

That is, all firms within a sector charge the same markup over marginal cost regardless of the location of the firm.

The sectoral price index is therefore a distance weighted sum of firms across the economy:

$$P_{sl}(t) = p_s \left(\sum_{l' \in L} (m_{sl'}(t)\delta_{sl'})^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}, \quad m_{sl'}(t) \equiv |N_{sl'}(t)| \quad (15)$$

Due to the Cobb-Douglas structure of C_l , we have:

$$P_l(k, t) = \prod_{s \in S} P_{sl}(t)^{\beta_s(k)} \quad (16)$$

Plugging this into the indirect utility function, we get:

$$U_j(k, t) = A_j(t) \frac{y(k, t)}{r_j(t)^{1-\phi(k)}} P_l(k, t)^{-\phi(k)} \quad (17)$$

Here the right hand side is a function only of the non-consumption amenities, the consumption price indices, and the preference parameters.

3.4.3 Fixed Costs and the Number of Firms

The full profit function for a firm in sector s in location l is given by scaled revenues minus fixed costs:

$$\pi_{sl}(t) = \frac{1}{\sigma_s} \left[\sum_{l \in L} \sum_{k \in K} \sum_{\omega \in \Omega} p_s^* \delta_{sl\omega} c_{sl\omega}^*(n, k, t) \mathcal{I}_{(l, \omega)}(k, t) \right] - f_{sl}(t, m_l(t)), \quad m_l(t) = \sum_{s \in S} m_{sl}(t) \quad (18)$$

We follow [Almagro and Domínguez-Iino \(2025\)](#) and assume that fixed costs are given by:

$$f_{sl}(t, m_l(t)) = \Lambda_l^s \Lambda_t m_l(t)^\psi \nu_{sl}(t) \quad (19)$$

Here $\nu_{sl}(t)$ is a unit mean lognormal independent random variable. Assuming free entry, Equation 18 and Equation 19 together pin down the number of firms.

3.5 Equilibrium

Fix an initial distribution of households $\{\mathcal{I}_j(k, 0)\}_{j \in J, k \in K}$ and a sequence of exogenous fundamentals $\{A_j(t), H_j(t), y(k, t), \delta_{sl\omega}(t), c_s, \Lambda_l, \Lambda_t, \nu_{sl}(t), \chi(k, t)\}_{0 \leq t \leq T}$. An equilibrium path is a sequence

$$\mathcal{E} = \{V_j(k, t), \mu_{jj'}(k, t), \mathcal{I}_j(k, t), r_j(t), \alpha_{\omega, j}(k, t), P_{sl}(t), m_{sl}(t)\}_{j, j' \in J, k \in K, s \in S, l \in L, 0 \leq t \leq T}$$

such that, for every t , the following conditions hold:

1. $V_j(k, t)$ and $\mu_{jj'}(k, t)$ are consistent with household utility maximization given prices,
2. $m_{sl}(t)$ and $P_{sl}(t)$ are consistent with profit maximization and free entry,
3. The sequence of residential choice populations $\mathcal{I}_j(k, t)$ are consistent with the law of motion $\mu_{jj'}(k, t)$,
4. Total city population $\mathcal{I}(k, t)$ is consistent with the entry indifference condition,
5. The floor space market clears.

4 Estimation

In order to estimate our structural model, we further aggregate our locations to parishes. A parish is a sub-municipal unit of geography which corresponds to the area served by a single Danish state church. Parishes tend to be smaller in historically densely population areas. In the CMA, there are 318 parishes. In order to estimate the model, we need sectoral firm numbers by parish, so this limits our sample to 1992-2014.

Private housing prices are the stock weighted mean square meter assessed price of housing by parish. As we do not have information on the price of public housing, we set it to one half of the observed private housing price.¹⁹ We use annual wage income terciles to define

¹⁹Since we estimate amenities separately by housing type in each location, any measurement error in public housing prices will be absorbed into the amenities estimate for public housing.

three household types, and set the model income to the average annual wage income within the tercile. A firm is taken to be an establishment tax id, and we divide firms into the same sectors as Table 3.

We use the structure of the model to split estimation into two parts. We first estimate the value of each choice at each time, the cost of moving, and the public housing access parameters using observed transition probabilities. Having estimated those objects, we estimate the components of flow utility.

4.1 Estimation Strategy

4.1.1 Values, Movement Costs, and Utility Shifter Equivalents

Define the deterministic part of the next-period payoff as:

$$W_{j'j}(k, t + 1) = V_j(k, t + 1) - \tau_{j'j}(k, t + 1)$$

The transition probabilities, $\mu_{jj'}(k, t)$, are given by:

$$\mu_{jj'}(k, t) = \frac{\exp(W_{jj'}(k, t))}{\sum_{j'' \in J} \exp(W_{jj''}(k, t))}, \quad W_{jj'}(k, t) \equiv V_{j'}(k, t) - \tau_{jj'}(k, t) - \alpha_{jj'}(k, t)$$

We use the following assumptions on $W_{jj'}(k, t)$ for identification:

$$W_{jj'}(k, t) = \begin{cases} V_{j'}(k, t), & \text{if } j = j' \\ V_{j'}(k, t) - \tau_{jj'}(k, t), & \text{if } j \neq j' \text{ and } j' = (l, 0) \\ V_{j'}(k, t) - \tau_{jj'}(k, t) - \alpha_{jj'}(k, t), & \text{if } j \neq j' \text{ and } j' = (l, 1) \end{cases} \quad (20)$$

Intuitively, when individuals rarely make a particular residential choice, it is hard to know if it is because the residential choice has low value, or because it is unlikely to be available.²⁰ We solve this problem with the assumption that an individual can always remain in their current residential choice. An individual will be unlikely to leave a high value residential choice, but likely to leave a low value residential choice.

We estimate $W_{jj'}(k, t)$ using PPML on transition counts, with $V_{j'}(k, t)$, $\tau_{jj'}(k, t)$, and $\alpha_{jj'}(k, t)$ as fixed effects.

4.1.2 Flow Utilities

Next we estimate the components of the flow utility function. We back out flow utility $U_j(k, t)$ as:²¹

$$U_j(k, t) = V_j(k, t) - \rho \left[\gamma + \ln \left(\sum_{j' \in J} \exp(W_{j'j}(k, t + 1)) \right) \right] \quad (21)$$

²⁰The identification challenge might be called the ‘‘sour grapes problem’’, after Aesop’s fox who assumed that the grapes were sour, when they were actually sweet but unavailable. Spatial economists estimating models without access constraints might make the same mistake regarding the desirability of locations.

²¹As is typical in discrete choice models, we must normalize our utility estimates. We set the flow utility of living outside the city to unity for all types and years.

4.1.3 Aggregate Consumption Parameters

We have already estimated the distance elasticities of consumption ξ_s in our public-housing privatization natural experiment summarized in Table 3. For our type-dependent Cobb-Douglas parameters $\beta_s(k)$, we calibrate using consumption shares from the Danish Household Budget Survey which are reported by income bands ([Statistics Denmark, 2026](#)). We take the simple mean values 1994-2014 for the three income bands which correspond to our terciles. We also calibrate the housing expenditure shares for the low, middle, and high income terciles to 0.35, 0.3, and 0.25 respectively.²²

4.1.4 Fixed Costs Estimation

Since we don't have information on production costs, we normalize $c_s = 1$ for all sectors. At this point we have estimated (or calibrated, or normalized) all parameters necessary to calculate gross profits in the firm's profit function (Equation 18). By the free entry condition, these gross profits must be equal to fixed costs. We recover the parameters in 19 using OLS with the estimating equation:

$$\ln(\hat{f}_{st}(t)) = \ln(\Lambda_i^s) + \ln(\Lambda_t) + \psi \ln(m_t(t)) + \ln(\nu_{st}(t)) \quad (22)$$

4.2 Estimation Results

In this section we summarize the key empirical objects recovered from the estimation procedure outlined above. We have access parameters α for each location and type in each year. To summarize these parameters, Panel A of Figure 5 plots the mean access parameter by type. The lower is the access parameter, the easier it is for the household to get into public housing. As can be seen, the low-income type have the easiest time accessing public housing, and the high-income type has the hardest time. Additionally, it is more difficult to get into public housing from private housing than from another public housing. This last pattern is expected, as public housing organizations often own several units, and have internal waiting lists. In Panel B of Figure 5 we show the mean access parameter by core (Copenhagen and Frederiksberg municipalities) and periphery (everything else). It is more difficult to get access public housing in the center of Copenhagen, as the waiting lists for housing in these desirable areas are longer than in other parts of the city.

We present normalized fixed costs in Panels C and D of Figure 5. These fixed costs are normalized by the unit cost of production, which we have set to one for all sectors. We find that fixed costs are lower in the core than in the periphery, which is likely due to the model explaining the large number of firms in the core of the city relative to the periphery. In Panel D we split mean fixed costs by sector. Supermarkets have relatively high fixed costs, restaurants have lower fixed costs and green grocers the lowest. Doctors, who often run small clinics, have even lower fixed costs, and primary schools the lowest of all.²³ We find the catch-all category other has the highest fixed costs. This is likely because there are a relatively large number of

²²In the next iteration of our estimation we will more carefully target housing expenditure shares from our data.

²³It is a bit difficult to interpret the primary school fixed costs, but during our data period heavily subsidized but private schools are quickly expanding in Copenhagen.

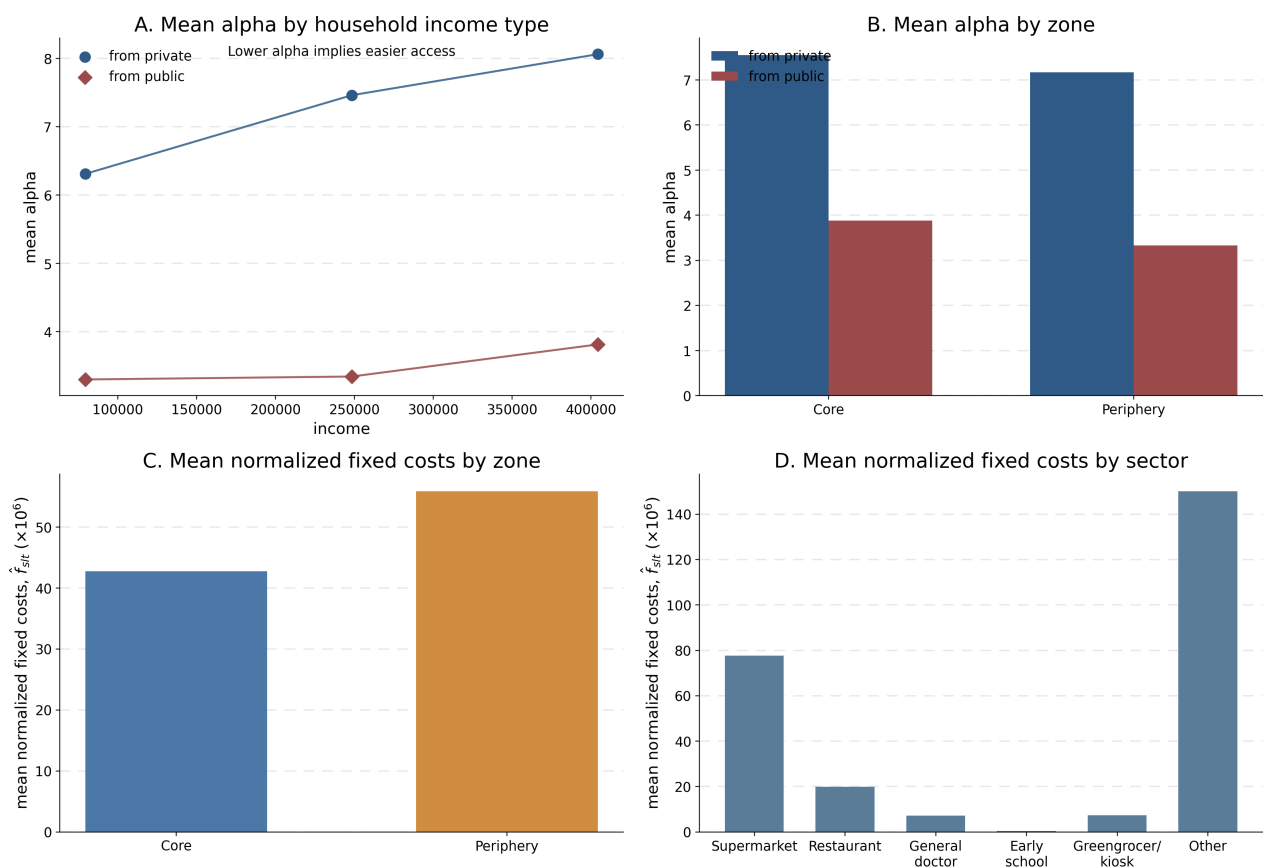


Figure 5: Access parameters and normalized fixed costs

Notes: Panel A plots mean access parameters α by household income type, pooling years. Lower α implies easier access. Panel B reports mean α in the core and the periphery, again pooling years, where the core is defined as Copenhagen and Frederiksberg municipalities. Panels C and D report mean normalized fixed costs, pooled over years. The normalization is that production cost is one in all sectors. Panel C aggregates normalized fixed cost by zone, and Panel D aggregates it by sector. In Panels C and D, values are reported in millions of current DKK.

other firms in many parishes, and our parameter estimates suggest that the more firms there are in a parish, the higher are fixed costs.

Table 4: Low-dimensional parameters

Sector	Expenditure share $\beta_s(k)$			Distance decay	Substitution
	$k = 1$	$k = 2$	$k = 3$	ξ_s	σ_s
Supermarket	0.231	0.187	0.175	0.030	2
Restaurant	0.073	0.061	0.059	0.100	2
General doctor	0.024	0.023	0.018	0.030	2
Primary school	0.00035	0.0013	0.0020	0.160	2
Greengroc./kiosk	0.026	0.021	0.019	0.300	2
Other	0.646	0.708	0.727	0.120	2
Distance slope, τ_k	0.216	0.265	0.287		
Fixed costs power, ψ				0.311	
Discount factor, ρ				0.92	

Notes: Each sector row reports the type-specific expenditure shares $\beta_s(k)$ together with the sector distance decay ξ_s and substitution elasticity σ_s . The three k columns correspond to income groups below 250,000 DKK, 250,000–449,999 DKK, and 450,000–699,999 DKK. The $\beta_s(k)$ entries are calibrated from Danish HBS FU05 averages over 1994–2014. The combined food-at-home share is split 90/10 between supermarket and greengrocer/kiosk. In the maintained parish branch, $\sigma_s = 2$ for all sectors, while ξ_s is fixed at reduced-form commuting-for-purchase decay values. The penultimate row reports the type-specific distance slopes τ_k estimated from observed residential transitions and route times. The next row reports the common firm fixed-cost exponent ψ scaling the contribution of the number of other firms in the market. The final row is the household discount factor.

Lower dimensional parameters are presented in Table 4. Our Cobb-Douglas expenditure shares show that in all categories except early school and other, the poor spend a higher share of their budget than do the rich. The slope of this expenditure is, however, different. The poorest type spends around 33% more on doctors and 32% more on grocery stores as a share of income than our richest type, but only 24% more on restaurants.²⁴ We find that supermarkets and doctors serve people far away, while restaurants, our catch-all category, and especially primary schools and kiosks serve people mostly nearby. Since we have no way to identify the elasticity of substitution within sectors, we simply fix them at two. Richer people face lower distance elasticities to moving their home than do poorer people, likely reflecting that richer people tend to move farther when they do move. We find that fixed costs increase with the number of firms in a location, reflecting competition for commercial floor space which we do not model. We fix the discount factor at 0.92, which implies that individuals care about their own welfare eight years in the future about half as much as they care about their welfare today.

5 How Changes in Public Housing Shape City Structure

Here we carry out a series of counterfactual exercises. We take the non-consumption amenities $A_j(t)$ as exogenous primitives, and start the city as it was observed in 1992. We then shock the economy with counterfactual changes in public housing stock. We consider two shocks:

²⁴We cannot separate expenditures on green grocers and grocery stores in the consumer expenditure data we use to calibrate these expenditure shares, so we just assign 90% of spending on food at home to grocery stores, and 10% to greengrocers/kiosks for each type.

conversion of all public housing to private housing and concentrating all public housing in a peripheral municipality (Gentofte).

5.1 Simulating the Counterfactual Equilibrium Path

This section describes how we construct counterfactual equilibrium paths. Our approach follows directly from the dynamic structure of the model and the estimated parameters summarized in Section 4.2. Given these inputs, the counterfactual simulations quantify how alternative public-housing policies reshape the spatial distribution of households, private housing prices, public-housing scarcity, and local consumption amenities over time.

The counterfactual equilibrium path is constructed jointly over the three core components of the model: (i) household location choices, (ii) housing-market clearing, and (iii) firm entry across consumption-amenity sectors. At each date t , and for a given candidate path of rents, public-housing scarcity, and firm counts, the household side is solved using the same dynamic choice structure as in the estimated model. In particular, transition probabilities are implied by the counterfactual flow utilities, movement costs, and public-housing access terms, together with the dynamic continuation values from the Bellman equation.

The algorithm has an outer and an inner loop. In the outer loop, households take the evolution of private housing rents, public housing access parameters, and firm locations as given, and optimally choose their location choices. If the housing markets do not clear, we adjust rents and access parameters in the direction of clearing each market.²⁵ We also allow firm numbers to adjust reflecting the locations of consumers. We also allow migration into and out of the city in the direction of clearing the entry indifference condition. The equilibrium path is therefore a fixed point in the joint evolution of household allocations, private rents, public-housing scarcity, and firm counts.

One important issue is that our baseline estimation relies on the transition probabilities in the final year of data to pin down the ending continuation value. We do not have to take a stand on what happens after that year, since that continuation value summarizes all the relevant beliefs of individuals. In the counterfactual, we have to take a stand on what happens in the final year. We assume that future non-consumption amenities, costs of entering the city, and all other time varying parameters become fixed at their last estimated value. In order to make these counterfactuals comparable to our baseline, we also simulate a version of our baseline under the assumption that our final estimated parameters become fixed forever.

We have neither a proof of uniqueness, nor do we believe that our equilibria are unique. In practice, we start with our baseline, and then smoothly change the baseline distribution of public housing towards our counterfactual distribution, solving the model repeatedly and iteratively along the way. In each iteration of this process, we use the last equilibrium as an initial guess for the next equilibrium. Our idea is that this will stop our estimation from jumping to an unlikely but possible counterfactual equilibrium (such as moving the downtown

²⁵We have access parameters for each household type by origin type in each location, but we only need to clear the single public housing market. We assume that rents paid for public housing do not adjust in our counterfactuals. In order to clear the market, we adjust all access parameters in a location up or down by a scalar. We set a floor on all access parameters of zero, to reflect free mobility into public-housing. Because even at that price, there may be excess supply, we allow the rent for public housing to fall, capturing the idea that the public housing organizations would prefer rent lower than cost rather than no rent at all.

of Copenhagen to a distant suburb).

5.2 Counterfactual Results

In this section, we present the results of our counterfactual experiments with public housing. First we discuss how these experiments affect the overall population of Copenhagen. The first panel in Figure 6 shows that our counterfactual experiments tend to drive population out of the CMA. The experiments also change the relative shares of household types living in the CMA. The lowest income type sees its population share increase in both experiments, while the two higher income types see their population share fall.

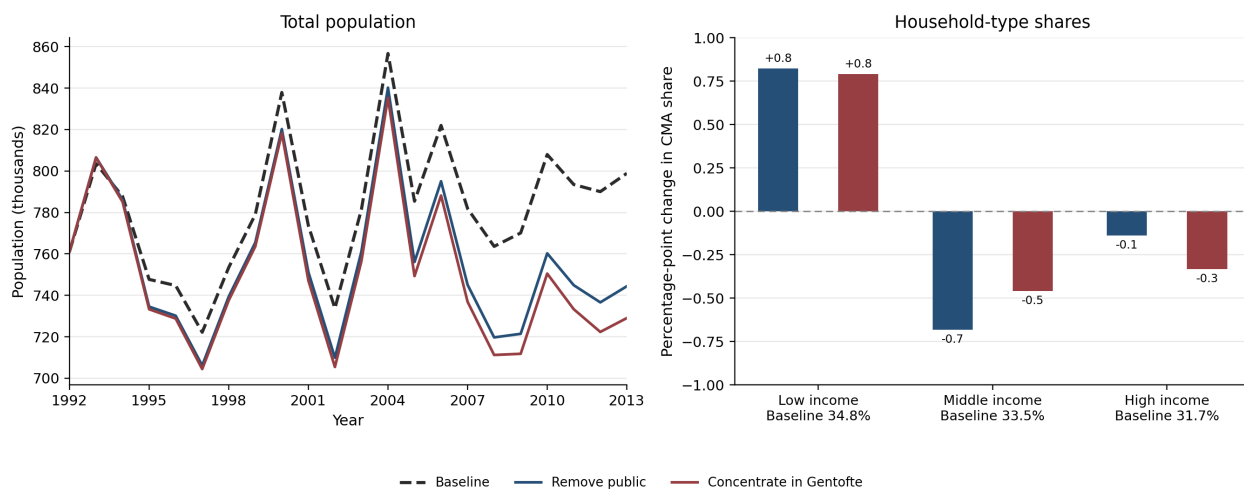


Figure 6: CMA population paths and household-type share changes

Notes: The left panel reports total in-area CMA household population paths. The right panel reports counterfactual minus baseline CMA household-type shares in percentage points in 2013.

To show how sorting is affected in each of our experiments, in the first two panels of Figure 7 we show the change in shares of household types in the last year of our experiment relative to the baseline. In both of our experiments, low and middle income households are pushed out of the center. The richest type of household also increases its share in the core in both experiments, which both involve removing public housing from the city’s core. The experiments both lead to more low income in the periphery and less middle income (who leave the city). In the last panel, we show the effect of firm sorting on the privatization counterfactual – the bars represent privatization with sectoral adjustment relative to without. While the effects are small, allowing firms to adjust increases the high income share in the core, and decreases the high income share in the periphery.

We show the effect of our counterfactuals on rents in Figure 8. For our privatization experiment, and our concentration of all public housing in Gentofte, the core becomes relatively expensive. Core vs periphery property prices are sometimes taken as a measure of gentrification. Under this definition, we see that privatization of public housing, or removing it from the core of the city, increases gentrification.

Finally, we zoom in on our experiment of moving all public housing to Gentofte municipality (incidentally one of the richest municipalities in the CMA). In Figure 9, Gentofte is the area on the right of Panel E with the massive fall in private rents. In order to clear the market, the

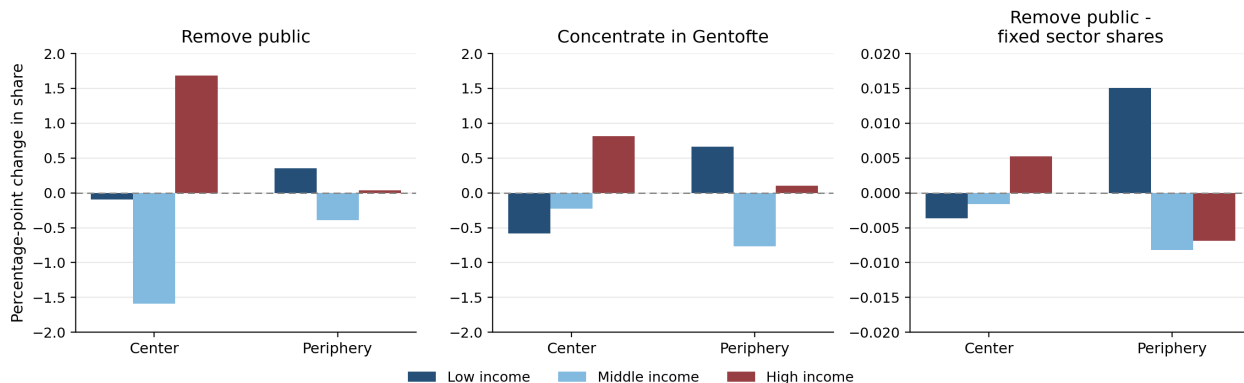


Figure 7: Zone household-share changes across counterfactuals

Notes: The first two panels report counterfactual minus baseline household-type shares in percentage points for the final comparison year 2014. The right panel reports remove-public minus remove-public-with-fixed-sector-shares household-type shares and uses its own y-axis scale. The center is defined as municipalities 101 and 147; all other in-area municipalities are in the periphery.

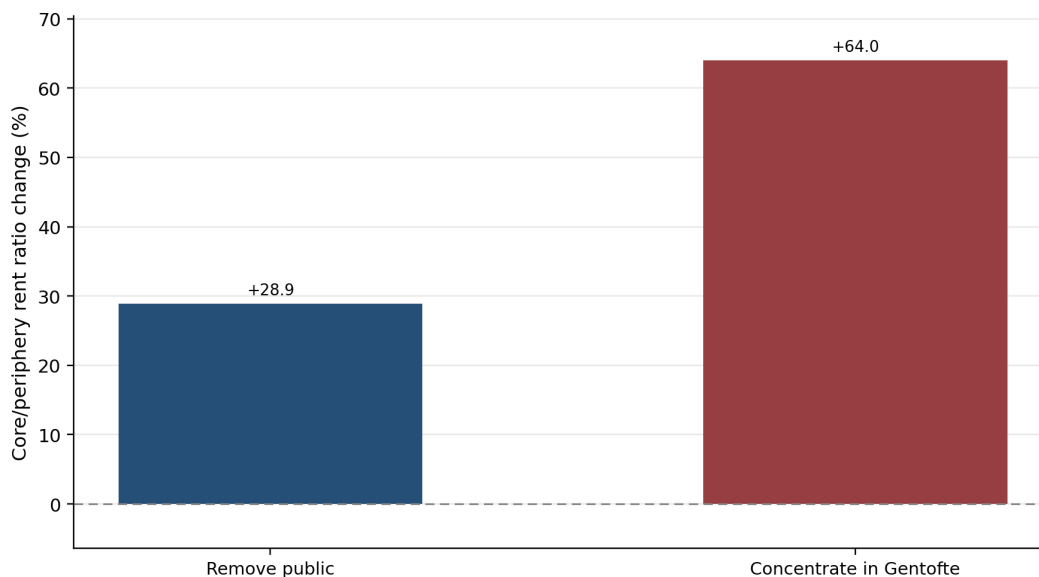


Figure 8: Relative change in core to periphery private rents across counterfactuals

Notes: Bars report the percent change in the core-to-periphery average private-rent ratio. Average rents are weighted by baseline housing stock. The core is defined as municipalities 101 and 147. All other in-area municipalities are assigned to the periphery. The comparison year is 2013.

access parameters adjust so that it becomes easy to get access to public housing in Gentofte. For the private market to clear, the rent has to fall. The top three panels show changes in population by household type relative to the baseline. The richest flee Gentofte as the lower and especially middle income types migrate in. Private rents increase in two parts of the CMA. They increase in the downtown area just to the south of Gentofte, and also in the more distant Northern and Western parts of the CMA. There is also subsequent sectoral sorting of firms. In particular, restaurants leave Gentofte, and many more open in the centrally located Copenhagen Municipality.

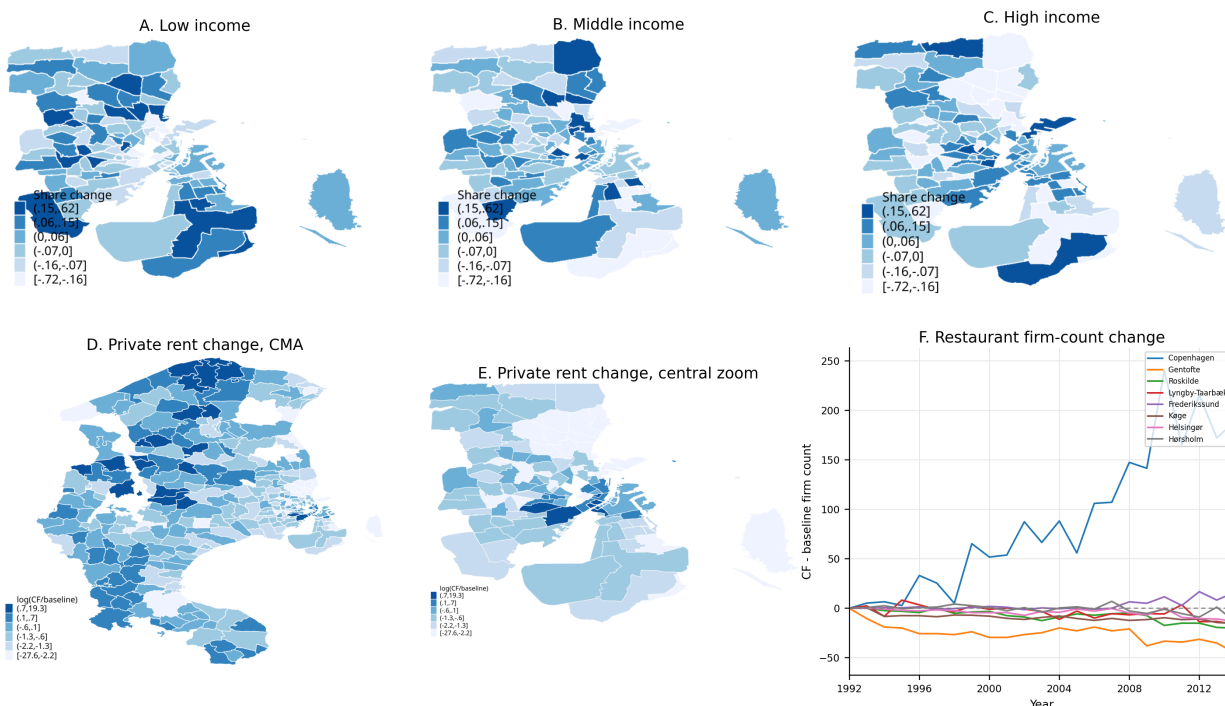


Figure 9: Household-share and private-rent changes under concentration in Gentofte
Notes: Panels A–C report final-year counterfactual minus baseline household-type shares for the central Copenhagen zoom. Panels D–E report final-year private-rent changes as for the full CMA and the central zoom. Panel F reports the counterfactual time series of restaurants by municipality. The Gentofte concentration counterfactual concentrates all baseline public housing in Gentofte. The central zoom contains municipality codes 101, 147, 155, 157, 159, 167, 173, 175, 185.

6 Conclusion

This paper examines how publicly provided, rent-regulated housing shapes the dynamics of urban gentrification. Leveraging rich administrative micro data for the Copenhagen Metropolitan Area covering 1986–2016 and a quasi-experimental reduction in the supply of public housing induced by the City of Copenhagen’s large-scale privatization, we document three empirical facts linking public housing to neighborhood composition, housing prices, and the supply of local consumption amenities. These reduced-form patterns highlight the central role of public housing in moderating the pace and spatial incidence of gentrification.

To interpret these findings and quantify underlying mechanisms, we develop a dynamic quan-

titative urban model in which households sort across neighborhoods subject to movement costs, private housing prices, and non-price rationing in the public-housing sector. The model incorporates endogenous consumption amenities and spatial spillovers, enabling a joint characterization of residential choices, firm entry, and price dynamics. The estimation strategy exploits the quasi-natural experiment to discipline key components of the model, including access probabilities for public housing, group-specific amenities, preferences for consumption goods, and the structure of fixed costs for local businesses.

Counterfactual simulations reveal that public housing has first-order effects on city structure. Eliminating the public-housing stock significantly increases the rental price ratio between the city's core and its periphery. Redistributing public housing across space similarly produces meaningful changes in neighborhood sorting of both households and firms, demonstrating that both the quantity and design of public housing policy shape urban development trajectories.

Taken together, our findings show that public housing acts as a stabilizing force in urban housing markets not merely by providing subsidized units to low-income households but by reshaping equilibrium prices and amenities. These insights underscore the importance of incorporating public housing into quantitative spatial models of cities and highlight the need for urban policy frameworks that account for both allocative and general-equilibrium effects. More broadly, the results point to a key mechanism through which housing policy can influence the long-run distributional and spatial consequences of urban transformation.

References

- Ahlfeldt, G. M., Heblich, S., and Seidel, T. (2023). Micro-Geographic Property Price and Rent Indices. *Regional Science and Urban Economics*, 98:103836.
- Ahlfeldt, G. M., Mulalic, I., Vieira, C. S., and Sturm, D. M. (2025). The geography of life: Evidence from Copenhagen. *Unpublished*.
- Ahlfeldt, G. M., Redding, S. J., Sturm, D. M., and Wolf, N. (2015). The economics of density: Evidence from the Berlin Wall. *Econometrica*, 83(6):2127–2189.
- Almagro, M., Chyn, E., and Stuart, B. A. (2023). Urban renewal and inequality: Evidence from Chicago’s public housing demolitions. *NBER Working Paper Series*, Working Paper 308380.
- Almagro, M., Chyn, E., and Stuart, B. A. (2024). Neighborhood revitalization and inequality: Evidence from Chicago’s public housing demolitions. Technical report, Technical Report. Working paper.
- Almagro, M. and Domínguez-Iino, T. (2025). Location sorting and endogenous amenities: Evidence from Amsterdam. *Econometrica*, 93(3):1031–1071.
- Autor, D. H., Palmer, C. J., and Pathak, P. A. (2014). Housing market spillovers: Evidence from the end of rent control in Cambridge, Massachusetts. *Journal of Political Economy*, 122(3):661–717.
- Baum-Snow, N. and Hartley, D. (2020). Accounting for central neighborhood change, 1980–2010. *Journal of Urban Economics*, 117:103228.
- Bayer, P. and Timmins, C. (2007). Estimating equilibrium models of sorting across locations. *The Economic Journal*, 117:353–374.
- Behrens, K., Boualam, B., Martin, J., and Mayneris, F. (2024). Gentrification and pioneer businesses. *The Review of Economics and Statistics*, 106(1):119–132.
- Behrens, K., Duranton, G., and Robert-Nicoud, F. (2014). Productive cities: Sorting, selection, and agglomeration. *Journal of Political Economy*, 122(3):507–553.
- Benabbou, N., Chakraborty, M., Ho, X.-V., Sliwinski, J., and Zick, Y. (2020). The price of quota-based diversity in assignment problems. *ACM Transactions on Economics and Computation*, 8(3):14:1–14:32.
- Borusyak, K., Jaravel, X., and Spiess, J. (2024). Revisiting Event-Study Designs: Robust and Efficient Estimation. *Review of Economic Studies*, 91(6):3252–3285.
- Brueckner, J. and Rosenthal, S. (2009). Gentrification and neighborhood housing cycles: Will America’s future downtowns be rich? *The Review of Economic Studies*, 76(3):723–756.
- Buurma-Olsen, J., Koster, J., van Ommeren, and Damsté, S. (2024). Quantifying Misallocation of Public Housing. *Journal of Public Economics*.
- Buurma-Olsen, J., Koster, H. R. A., van Ommeren, J., and Sinninghe Damsté, J. (2025). Quantifying misallocation of public housing. *Journal of Public Economics*, 242:105272.

- Callaway, B. and Sant’Anna, P. H. (2021). Difference-in-Differences with Multiple Time Periods. *Journal of Econometrics*, 225(2):200–230.
- Christensen, I. and Stax, T. B. (2002). Kommunal boliganvisning: En analyse af praksis og politik i Københavns Kommune. Working paper, Socialforskningsinstituttet, København.
- Couture, V. and Handbury, J. (2020). Urban revival in America. *Journal of Urban Economics*, 119:103267.
- Cremer, H., Marchand, M., and Thisse, J.-F. (1989). The public firm as an instrument for regulating an oligopolistic market. *Oxford Economic Papers*, 41(2):283–301.
- Davis, D. R., Dingel, J., Monras, J., and Morales, E. (2019). How segregated is urban consumption? *Journal of Political Economy*, 127(4):1684 – 1738.
- De Fraja, G. and Delbono, F. (1989). Alternative strategies of a public enterprise in oligopoly. *Oxford Economic Papers*, 41(2):302–311.
- Desai, M. A., Dharmapala, D., and Singhal, M. (2010). Tax incentives for affordable housing: The Low Income Housing Tax Credit. *Tax Policy and the Economy*, 24(1):181–205.
- Diamond, R. (2016). The determinants and welfare implications of U.S. workers’ diverging location choices by skill: 1980-2000. *Quarterly Journal of Economics*, 131(4):1329–1378.
- Diamond, R. and Gaubert, C. (2022). Spatial sorting and inequality. *Annual Review of Economics*, 14:795–819.
- Diamond, R. and McQuade, T. (2019). Who wants affordable housing in their backyard? An equilibrium analysis of low-income property development. *Journal of Political Economy*, 127(3).
- Diamond, R., McQuade, T., and Qian, F. (2019). The effects of rent control expansion on tenants, landlords, and inequality: Evidence from San Francisco. *American Economic Review*, 109(9):3365–3394.
- Eeckhout, J., Pinheiro, R., and Schmidheiny, K. (2014). Spatial sorting. *Journal of Political Economy*, 122(3):554–620.
- Einav, L., Finkelstein, A., Ryan, S. P., Schrimpf, P., and Cullen, M. R. (2013). Selection on moral hazard in health insurance. *American Economic Review*, 103(1):178–219.
- Ellen, I. G. and O’Regan, K. M. (2011). How low income neighborhoods change: Entry, exit, and enhancement. *Regional Science and Urban Economics*, 41:89–97.
- Glaeser, E. L., Kim, H., and Luca, M. (2018). Nowcasting gentrification: Using Yelp data to track neighborhood change. *American Economic Review: Papers & Proceedings*, 108:77–82.
- Glaeser, E. L. and Luttmer, E. F. P. (2003). The Misallocation of Housing Under Rent Control. *American Economic Review*, 93(4):1027–1046.
- Guerrieri, V., Hartley, D., and Hurst, E. (2013). Endogenous gentrification and housing price dynamics. *Journal of Public Economics*, 100:45–60.
- Gyourko, J., Mayer, C., and Sinai, T. (2006). Superstar cities. *Quarterly Journal of Economics*, 121(2):507–550.

- H. Hanson, G. (2005). Market potential, increasing returns and geographic concentration. *Journal of International Economics*, 67(1):1–24.
- Haltiwanger, J. C., Kutzbach, M. J., Palloni, G., Pollakowski, H. O., Staiger, M., and Weinberg, D. H. (2024). The children of HOPE VI demolitions: National evidence on labor market outcomes. *Journal of Public Economics*, 239:105188.
- Heblich, S., Redding, S. J., and Sturm, D. M. (2020). The Making of the Modern Metropolis: Evidence from London. *The Quarterly Journal of Economics*, 135(4):2059–2133.
- Hoxby, C. M. (2000). Does competition among public schools benefit students and taxpayers? *American Economic Review*, 90(5):1209–1238.
- Hwang, J. and Lin, J. (2016). What have we learned about the causes of recent gentrification? *Cityscape*, 18(3):9–26.
- Kholodilin, K. A. (2024). Rent control effects through the lens of empirical research. *Journal of Housing Economics*, 65:101997.
- Kholodilin, K. A., Kohl, S., and Müller, F. (2024). The rise and fall of social housing? housing decommodification in long-run comparison. *Journal of Social Policy*, 53(4):970–996.
- Kline, P. and Moretti, E. (2014). Local economic development, agglomeration economies, and the big push: 100 years of evidence from the Tennessee Valley Authority. *The Quarterly Journal of Economics*, pages 275–331.
- Københavns Kommune (2024). Boligreguleringen 2024.
- Kuminoff, N. V., Smith, V. K., and Timmins, C. (2013). The new economics of equilibrium sorting and policy evaluation using housing markets. *Journal of Economic Literature*, 51(4):1007–1062.
- Lee, Y., Kemp, P. A., and Reina, V. J. (2022). Drivers of housing (un)affordability in the advanced economies: A review and new evidence. *Housing Studies*, 37(10):1739–1752.
- Lees, L., Slater, T., and Wyly, E. (2008). *Gentrification*. Routledge, New York and London.
- Lucas, R. E. and Rossi-Hansberg, E. (2002). On the internal structure of cities. *Econometrica*, 70(4):1445–1476.
- Mahoney, N. (2015). Bankruptcy as implicit health insurance. *American Economic Review*, 105(2):710–746.
- McFadden, D. (1974). The measurement of urban travel demand. In Zarembka, P., editor, *Frontiers in Econometrics*, pages 105–142. Academic Press, New York.
- Melo, P. C., Graham, D. J., and Noland, R. B. (2009). A meta-analysis of estimates of urban agglomeration economies. *Regional Science and Urban Economics*, 39(3):332–342.
- Moreno-Maldonado, A. and Santamaria, C. (2024). Delayed childbearing and urban revival: A structural approach. *CEPR Discussion Papers*, (Discussion paper 19002).
- Nielsen, R. S. and Haagerup, C. D. (2017). The danish social housing sector: Recent changes and future challenges. *Critical Housing Analysis*, 4(1):142–149.

- Olsen, E. O. (1988). Rent control and the supply of housing. *Regional Science and Urban Economics*, 18(2):221–231.
- Rasmussen, M. (2002). Har salget af københavns kommunes boliger forringet mulighederne for lavindkomstgrupper? statistisk karakteristik af indflyttere i ”tor-boliger”. Arbejdsrapport 25, Socialforskningsinstituttet (The Danish National Institute of Social Research), Copenhagen, Denmark.
- Redding, S. J. (2025). Chapter 2 - quantitative urban economics. In Donaldson, D. and Redding, S. J., editors, *Handbook of Regional and Urban Economics*, volume 6 of *Handbook of Regional and Urban Economics*, pages 73–141. Elsevier.
- Redding, S. J. and Rossi-Hansberg, E. (2017). Quantitative spatial economics. *Annual Review of Economics*, 9:21–58.
- Redding, S. J. and Sturm, D. M. (2024). Neighborhood effects: Evidence from wartime destruction in London. *NBER Working Paper Series*, Working Paper 32333.
- Rosenthal, S. S. and Strange, W. C. (2001). The determinants of agglomeration. *Journal of Urban Economics*, 50(2):191–229.
- Rosenthal, S. S. and Strange, W. C. (2004). Chapter 49 - evidence on the nature and sources of agglomeration economies. In Henderson, J. V. and Thisse, J.-F., editors, *Cities and Geography*, volume 4 of *Handbook of Regional and Urban Economics*, pages 2119–2171. Elsevier.
- Schiff, N. (2014). Cities and product variety: evidence from restaurants. *Journal of Economic Geography*, 15(6):1085–1123.
- Sims, D. P. (2007). Out of control: What can we learn from the end of Massachusetts rent control? *Journal of Urban Economics*, 61(1):129–151.
- Statistics Denmark (2026). FU05: Group of consumption. <https://www.statbank.dk/FU05>. StatBank Denmark, Household Budget Survey. Accessed 2026-04-23.
- Su, Y. (2022). The rising value of time and the origin of urban gentrification. *American Economic Journal: Economic Policy*, 14(1):402–439.
- Sun, L. and Abraham, S. (2021). Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects. *Journal of Econometrics*, 225(2):175–199.
- Waldinger, D. (2021). Targeting in-kind transfers through market design: A revealed preference analysis of public housing allocation. *American Economic Review*, 111(8):2660–2696.

Online Appendix for “The Geography of Public Housing and the Dynamics of City Structure”

Filip Sangild Beck
CBS

David Jenkins
CBS

Ismir Mulalic
CBS

November 2025

Table of Contents

A	Additional Background	2
A1	Comparative Policy Architecture	2
A2	The TOR Privatization	2
B	Additional Empirical Results	6
C	Model Proofs and Derivations	8
C1	Housing Market	8
C2	Consumption Amenities	9

A Additional Background

A1 Comparative Policy Architecture

While public housing is widespread globally, the amount varies greatly, with the public housing rate (the share of the housing stock that consists of public housing) standing at between roughly 15% and 30% in places such as Denmark, Scotland, France, and the Netherlands (Kholodilin et al., 2024). In contrast the public housing rate has never exceeded 10% in the US and currently stands far below that level (Kholodilin et al., 2024). The low level of public housing in US is particularly due to the fact that the new supply of affordable housing is primarily driven by private developers through the 1986 Low-Income Housing Tax Credit scheme (Desai et al., 2010). At the same time, much of the existing US public housing was demolished in the 1990s during initiatives such as HOPE VI (Haltiwanger et al., 2024; Almagro et al., 2024).

There is substantial heterogeneity in the institutions governing the allocation of public housing in different countries. In general public housing allocation mechanisms give preferential treatment to low-income or vulnerable groups, but may be open to the broad population to varying degrees. In the US, Netherlands, France, and Singapore for example public housing allocation mechanisms target the most disadvantaged groups primarily through an income ceiling eligibility criterion. In the US for example there is a general strict requirement that household income is below 80% of the local median, often along with a points based system prioritizing elderly, disabled, or homeless individuals and/or waiting lists or lotteries (Waldinger, 2021). In the Netherlands there is a fixed national income ceiling eligibility criterion that applies to at least 90% of the public housing stock. The remaining public housing is reserved for vulnerable priority groups (Buurma-Olsen et al., 2025). In Singapore, the public housing allocation mechanism likewise targets vulnerable low-income households with an income ceiling eligibility criterion, but the waiting list is arranged through a lottery system (Benabbou et al., 2020). In Denmark, in contrast, public housing is in principle open to everyone, but around 25% of the public housing stock can be reserved for the most vulnerable groups in the municipality and in general priority is given to low-income and vulnerable household groups (Nielsen and Haagerup, 2017).

A2 The TOR Privatization

In the early 1990s, the Municipality of Copenhagen faced a significant challenge with its rental apartments. With 19,000 units spread across 235 properties, comprising around 7% of the municipality’s housing stock, these dwellings had become a financial burden. To address this issue, the municipality took the decision in 1994 to sell off all 19,000 apartments.

The driving force behind this move was the Municipality of Copenhagen’s budget crisis. The municipality found itself in a severe financial situation, facing a deficit of DKK 2.9 billion in its budget proposal for 1995. The municipality had at the time a higher concentration of pensioners, unemployed individuals, singles, and socially challenged individuals than any other municipality in the country. This further strained the municipality’s resources, while tax revenues failed to grow at the same rate as the rest of the country.

To address these challenges, the sale of the rental properties was part of a broader financial

agreement between the municipality and the general government. The immediate objective was to prevent the municipality from falling under administration. In the long term, the plan aimed to put the municipality's financial back on track. Overall, the decision to sell off the rental properties was a necessary step for the Municipality of Copenhagen to alleviate its economic burden.

The apartments were first sold to the municipal-state real estate company TOR for a public assessed value of DKK 3.235 billion. The company TOR, was established by the municipality and the Ministry for Housing with the aim of reselling the dwellings, which had happened in the year 2000, so the company terminated. The majority of the amount went towards paying off the municipality's debt to the state. TOR was established with the aim of selling the properties within 15 years.

The residents were given two opportunities to take over the apartments as cooperatives: first, when TOR acquired the properties, and second, when they were resold to a third party. Shortly after acquiring the properties, TOR sent out flyers to the tenants. These flyers served to inform them of the opportunity to purchase their apartments through a cooperative scheme. Alongside this information, the leaflets also included a guide describing the process of apartment acquisition. The residents were encouraged to engage in discussions, establish an association, elect a representative, and seek legal counsel. They were also advised to explore financing options, maintain open communication with TOR, and be prepared to act quickly.

There was significant interest among the residents in becoming cooperative owners. By 1998, there were only a few homes left for sale. Out of the total 19,000 dwellings, 16,500 were sold as cooperatives, 600 to non-profit housing associations (public housing), and 1,400 to private landlords. The remaining 500 homes took longer to sell, as they were often small properties in unfavorable locations with limited potential for development, or they were expensive due to prior urban renewal efforts.

Municipality owned apartments were rented out using waiting and priority lists. TOR took over not only the properties, but also a team of 220 staff members and the responsibility of managing waiting and priority lists. The priority list played a significant role. In the year 1993, 1800 out of 2300 new tenancies had been allocated on the basis of social reasons. TOR was expected to secure the highest possible selling price while ensuring the municipality's continued ability to provide housing for citizens with urgent needs. However, if the homes were sold to co-operatives, the allocation through the priority list would be completely eliminated. [Christensen and Stax \(2002\)](#) shows that the priority lists for standard public housing have significantly increased from 2000 to 2002 (the number on the waiting list was 357 in 2000, 451 in 2001 and 772 in 2002). Furthermore, [Christensen and Stax \(2002\)](#) identified a shift in the criteria for priority list assignments. Rather than primarily financial considerations, other factors such as psychological issues or substance abuse problems were increasingly taken into account. Consequently, individuals facing economic challenges, or other social or health-related issues were more likely to be observed on standard waiting lists for public housing.

During the privatization process, the properties were classified into three categories based on several factors including the property's size, location, quality, condition, and rental rate. "Prime properties" ("Gode ejendomme" in Danish) were sold without the possibility for the municipality to rent out the apartments through priority lists. "Average properties" were restricted to a maximum of 50% ("Mellemgode ejendomme" in Danish). For "Bad properties"

the municipality could rent out up to 50% the apartments through priority lists (“Dårlige ejendomme” in Danish).

TOR owned a large number of homes that were classified as "other type os housing" in 1996-1998, see Table A.1. However, starting from 1997, the majority of these homes were sold to cooperative housing. Only a small portion transferred to public housing associations and private rental housing.

Table A.1: Total housing stock (1000 sqm) in the municipality of Copenhagen, by ownership type

Year	Municipality of Copenhagen	Public housing	Cooperative housing	Other types of housing	Total
1990	1,580	3,382	4,107	15,124	24,194
1991	1,510	3,495	4,205	15,037	24,247
1992	1,501	3,547	4,339	14,908	24,296
1993	1,458	3,595	4,427	14,907	24,387
1994	1,441	3,648	4,457	14,859	24,405
1995	1,442	3,714	4,536	14,837	24,528
1996	192	3,755	4,737	16,014	24,699
1997	168	3,828	5,033	15,730	24,760
1998	158	3,942	5,650	15,091	24,841
1999	166	3,941	6,018	14,802	24,926
2000	173	3,944	6,164	14,733	25,014

Moreover, Figure A.1 shows that privatized public housing is relatively evenly distributed across the Municipality of Copenhagen, with the exception of the historical city center, where commercial activity is more prevalent.

To ensure that the municipality received fair value for the properties and that residents did not overpay, the properties were sold based on broker valuations. However, these valuations were significantly below the public assessment values. Consequently, when the company was dissolved in 2000, TOR incurred a deficit of DKK 1 billion, which had to be covered by the general government. The sale of the properties was met with criticism. It was called “Denmark’s worst real estate transaction.” It was argued that the sale constituted hidden state transfer to the municipality of Copenhagen. This criticism stemmed from the fact that the state owned only 15% of the property company, while the Municipality of Copenhagen owned the remaining 85%. Additionally, it was revealed that the state would cover potential losses of up to DKK 3.3 billion incurred by TOR.

The majority of the apartments were ultimately sold to the residents on a cooperative basis, marking a significant shift in the housing situation for many individuals. This transition allowed them to move from rental arrangements to cooperative housing, while also introducing a new housing policy that had a profound impact on the municipality. As a result, this policy played an important role in changing the composition of residents and preventing the municipality from bankruptcy. Furthermore, this initiative attracted and retained citizens who would positively contribute to the local economy. The agreement stressed the importance of collaborating to keep tax-attractive individuals within the municipality. This necessitated a

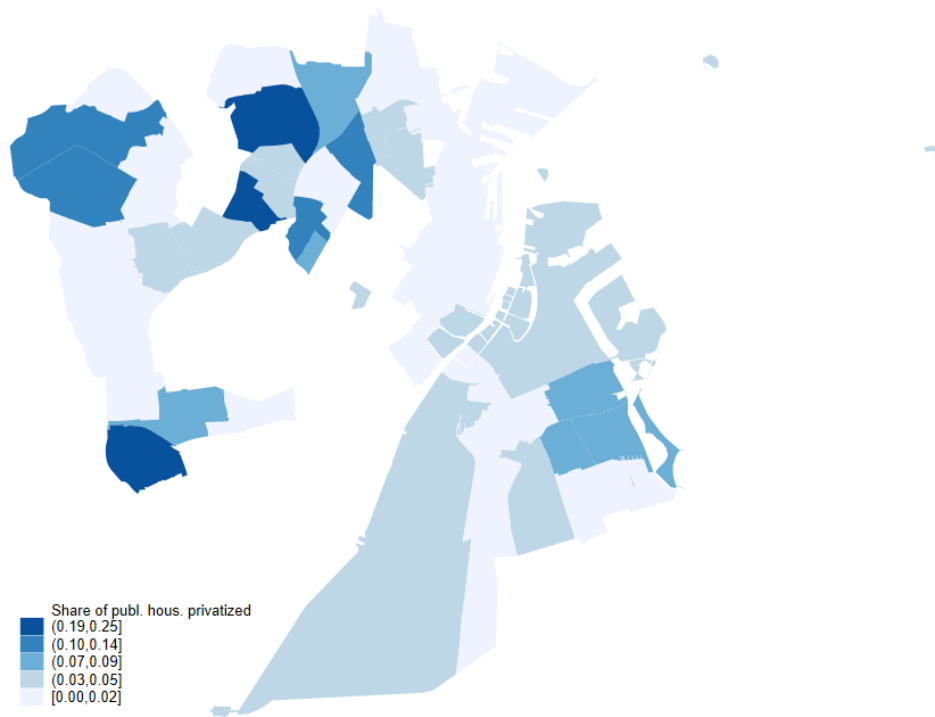


Figure A.1: Share of public housing units privatized, by parish

change in the demographic composition of the city, although no direct correlation was established between these shifts and the sale of municipality owned dwellings.

According to [Rasmussen \(2002\)](#), the sale of municipality-owned dwellings in 1994 can be regarded as a natural experiment. Furthermore, [Rasmussen \(2002\)](#) argues that this sale had a significant impact on neighborhood composition and public housing within the municipality of Copenhagen.

B Additional Empirical Results

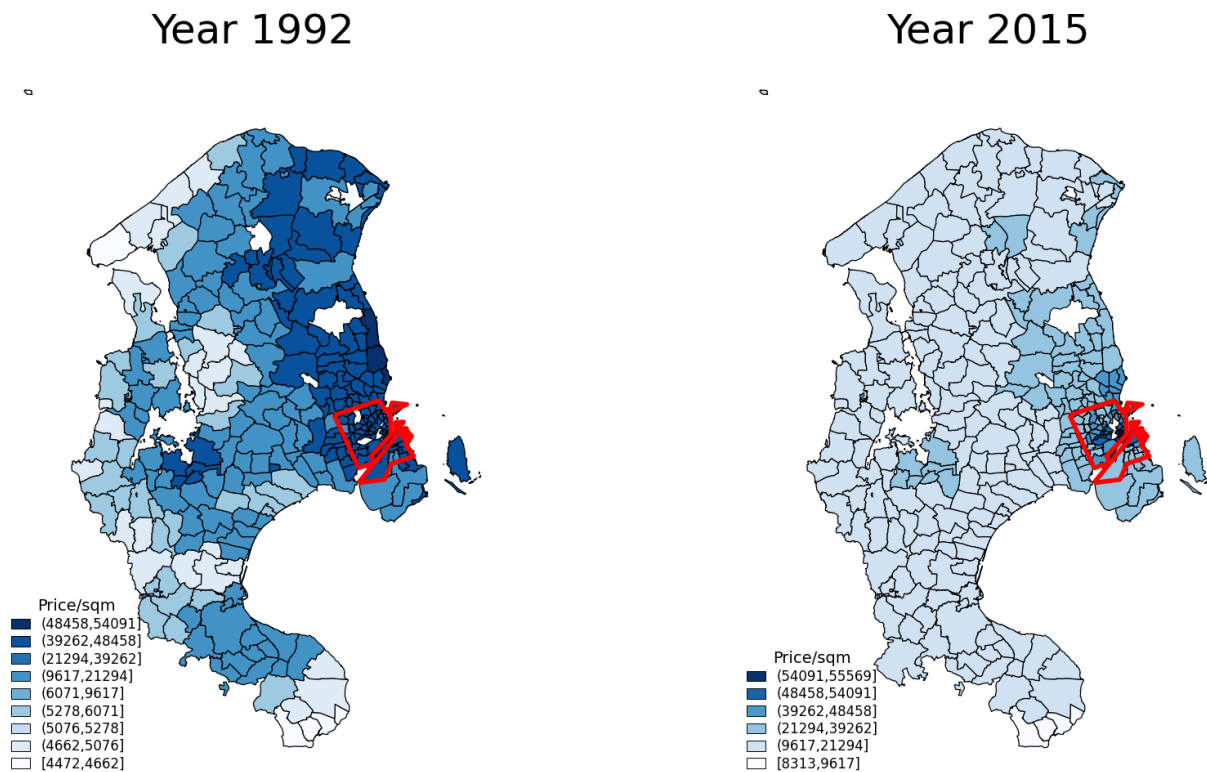


Figure B.1: HPI (DKK/sqm) by parish for years 1992 and 2015

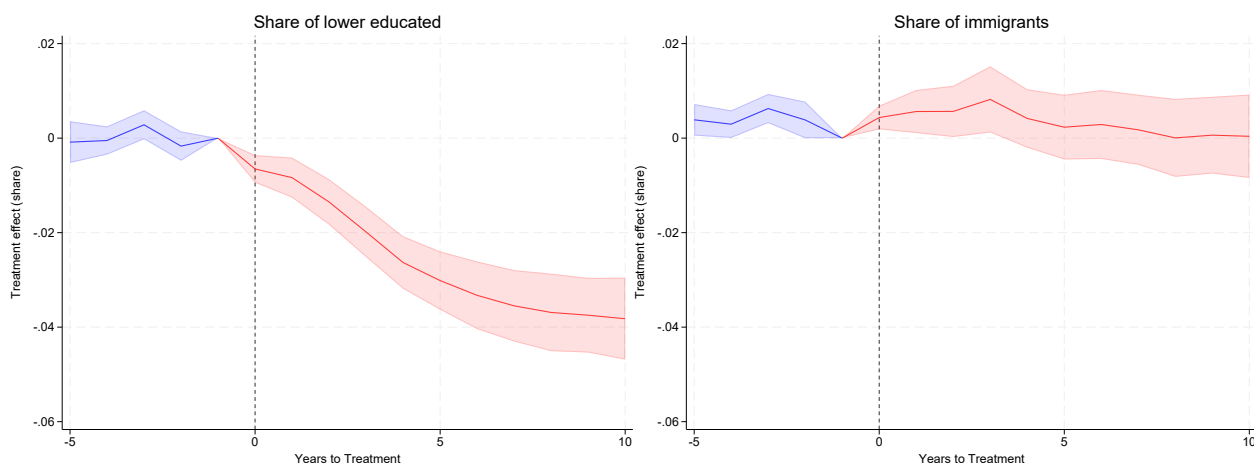


Figure B.2: Impact of Public Housing Privatization on Share of Immigrants and Lower Educated

Notes: Each panel illustrates the impact of public housing privatization defined in Eq. (1).

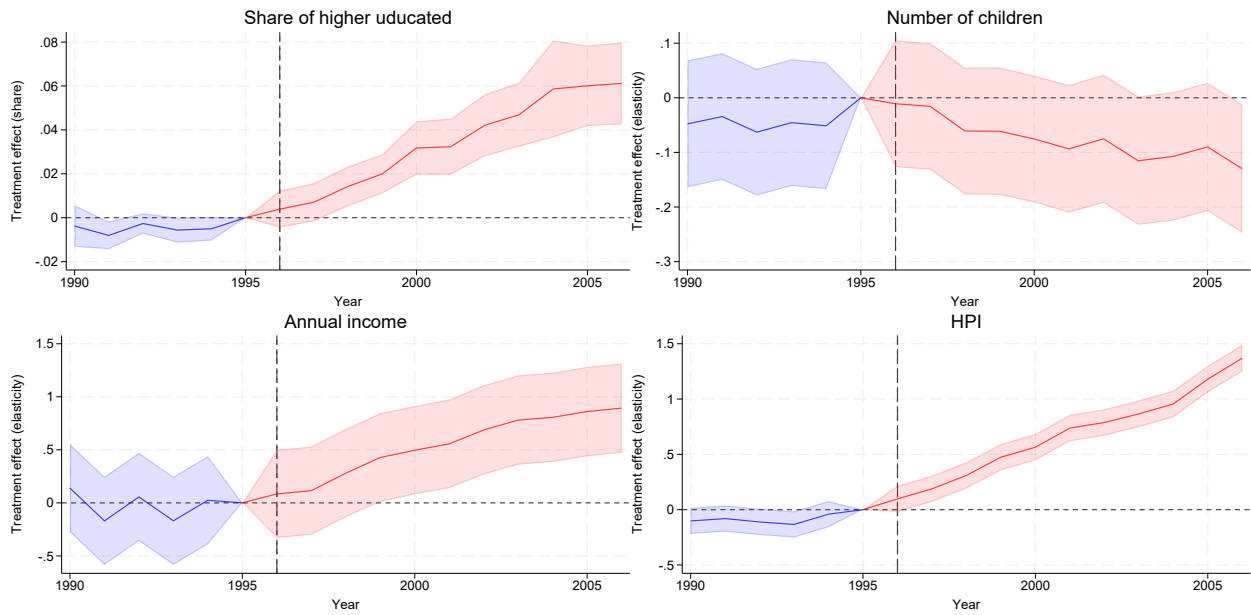


Figure B.3: Impact of Public Housing Privatization: treatment indicator interacted with the share of public housing privatized in each neighborhood.

Notes: Each panel illustrates the impact of public housing privatization defined in Eq. (1) in which the treatment indicator is interacted with the share of public housing privatized in each neighborhood.

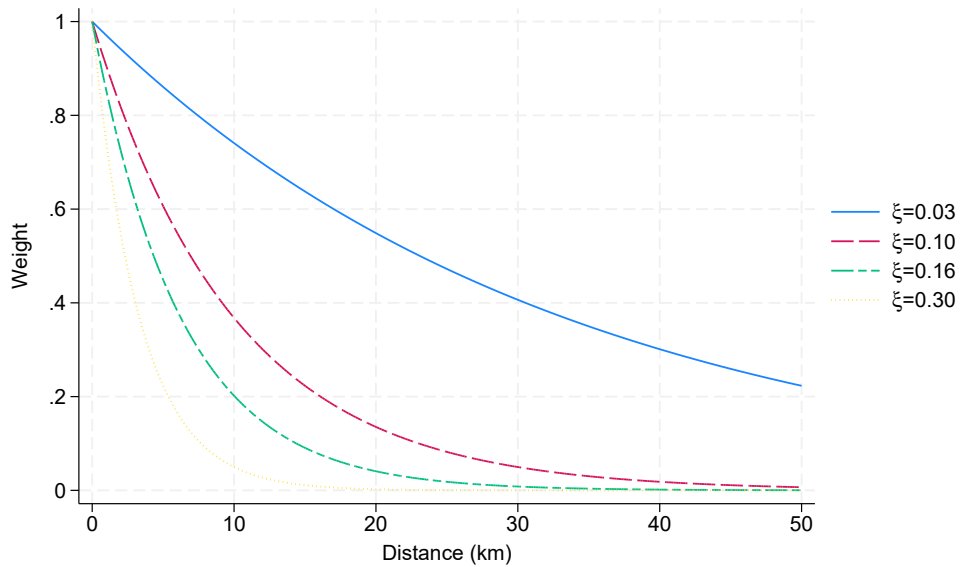


Figure B.4: Decay

Notes: Weights are defined as $\exp(-\xi d)$ where ξ denotes the spatial decay parameter and d represents walking travel time.

C Model Proofs and Derivations

C1 Housing Market

C1.1 Derivation of the Utility Shifter Equivalent

The probability that an individual from group k who resides in j moves to j' at time t is given by:

$$\begin{aligned} \mu_{jj'}(k, t) &= \sum_{J' \in \mathcal{P}(J)} \mathbb{P}(J|j, k, t) \frac{\mathbb{1}\{j' \in J\} \exp(V_{j'}(k, t) - \tau_{jj'}(k, t))}{\sum_{j'' \in J'} \exp(V_{j''}(k, t) - \tau_{jj''}(k, t))} \\ &= a_{jj'}(i, t) \cdot \exp(V_{j'}(k, t) - \tau_{jj'}(k, t)), \end{aligned} \quad (\text{C.1})$$

$$a_{jj'}(i, t) \equiv \mathbb{P}(j'|j, k, t) \sum_{J' \in \mathcal{P}(J \setminus \{j'\})} \mathbb{P}(J'|j', j, k, t) \frac{1}{\sum_{j'' \in J' \cup \{j'\}} \exp(V_{j''}(k, t) - \tau_{jj''}(k, t))}$$

Here $\mathcal{P}(J)$ denotes the power set of J , $\mathbb{P}(J'|j', j, k, t)$ is the probability that an individual from group k residing in j has access to the choice set $J' \cup \{j'\} \subseteq J$ at time t given that the individual has access to j' , and $\mathbb{P}(j'|j, k, t)$ is the probability that an individual from group k residing in j has access to alternative j' at time t .

Rewriting $a_{jj'}(k, t) = a'_{jj'}(k, t)b_j(k, t)$ and imposing the constraint that the transition probabilities sum to one, we get:

$$\begin{aligned} 1 = b_j(k, t) \sum_{j' \in J} a'_{jj'}(k, t) \exp(V_{j'}(k, t) - \tau_{jj'}(k, t)) &\Leftrightarrow b_j(k, t) = \frac{1}{\sum_{j' \in J} a'_{jj'}(k, t) \exp(V_{j'}(i, t) - \tau_{jj'}(k, t))} \\ \Leftrightarrow \mu_{jj'}(k, t) &= \frac{a'_{jj'}(k, t) \exp(V_{j'}(k, t) - \tau_{jj'}(k, t))}{\sum_{j'' \in J} a'_{jj''}(k, t) \exp(V_{j''}(k, t) - \tau_{jj''}(k, t))} \end{aligned} \quad (\text{C.2})$$

Define $\alpha_{jj'}(k, t) \equiv -\ln(a'_{jj'}(k, t))$, which denotes the utility shifter equivalent that rationalizes the transition probabilities, $\mu_{jj'}(k, t)$, of all groups under rationing.

C1.2 Approximation of the Choice Set Inclusion Probabilities

Assuming that $\mathbb{P}(J'|j', j, k, t) \approx 0$ whenever $j'' \in J' \subseteq J \setminus \{j'\}$ for any $j'' = (l'', 1) \neq j'$, such that the probability that an individual has access to public housing in more than one location within any period is close to zero, the choice set inclusion probabilities map approximately to the utility shifter equivalents according to (see Equation C.1 and Equation C.2):

$$\mathbb{P}(j'|j, k, t) \approx \exp(-\alpha_{jj'}(k, t)) \quad (\text{C.3})$$

This approximation is likely to hold when the number of free public housing units is small relative to the total number of individuals within each period.

C2 Consumption Amenities

C2.1 Derivation of Individual Demand

Within each sector s , location l individuals consume the following Dixit–Stiglitz CES aggregate of varieties produced at all origins l' :

$$Q_{sl}(k, t) = \left[\sum_{l' \in L} \sum_{n \in N_{sl'}(t)} (q_{sl'}(n, k, t) / \delta_{sl'}(t))^{\frac{\sigma_s - 1}{\sigma_s}} \right]^{\frac{\sigma_s}{\sigma_s - 1}} \quad (\text{C.4})$$

Each firm sets a single undifferentiated mill price $p_{sl'}(n, t)$. The final utility from consumption is adjusted downwards by $\delta_{sl'}(t) \geq 1$. Let group k individuals' expenditure within sector s be denoted as $y_s^C(k, t)$. Finally, $N_{sl'}(t)$ denotes the set of firms in sector s in location l' at time t .

Now for a given set of prices, $\{p_{sl'}(n, t)\}$, maximize the utility from local consumption amenities consumption, $Q_{sl}(k, t)$, under the budget constraint:

$$\begin{aligned} & \max_{\{q_{sl'}(n, k, t)\}} \sum_{l' \in L} \sum_{n \in N_{sl'}(t)} (q_{sl'}(n, k, t) / \delta_{sl'}(t))^{\frac{\sigma_s - 1}{\sigma_s}}, \\ \text{s.t. } & \sum_{l' \in L} \sum_{n \in N_{sl'}(t)} p_{sl'}(n, t) q_{sl'}(n, k, t) \leq y_s^C(k, t) \equiv \phi(k, t) \psi(k, t) \beta_s(k, t) y(k, t) \end{aligned}$$

The Lagrangian is:

$$\mathcal{L} = \sum_{l' \in L} \sum_{n=1}^{N_{sl'}(t)} (q_{sl'}(n, k, t) / \delta_{sl'}(t))^{\frac{\sigma_s - 1}{\sigma_s}} + \lambda \left(y_s^C(k, t) - \sum_{l' \in L} \sum_{n=1}^{N_{sl'}(t)} p_{sl'}(n, t) q_{sl'}(n, k, t) \right), \quad \lambda \geq 0$$

For each location l' and each variety n , the first-order condition is:

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial q_{sl'}(n, k, t)} &= \frac{\sigma_s - 1}{\sigma_s} \delta_{sl'}(t)^{\frac{1 - \sigma_s}{\sigma_s}} q_{sl'}^*(n, t)^{-\frac{1}{\sigma_s}} - \lambda p_{sl'}(n, t) = 0 \\ \Rightarrow q_{sl'}^*(n, t) &= \left(\frac{\sigma_s - 1}{\sigma_s} \right)^{\sigma_s} \delta_{sl'}(t)^{1 - \sigma_s} (\lambda p_{sl'}(n, t))^{-\sigma_s} \end{aligned}$$

Now let the constraint bind:

$$y_s^C(k, t) = \sum_{l' \in L} \sum_{n \in N_{sl'}(t)} p_{sl'}(n, t) q_{sl'}^*(n, k, t) = \left(\frac{\sigma_s - 1}{\lambda \sigma_s} \right)^{\sigma_s} \sum_{l' \in L} \sum_{n \in N_{sl'}(t)} p_{sl'}(n, t)^{1 - \sigma_s},$$

$$p_{sl'}(n, t) \equiv \delta_{sl'}(t) p_{sl'}(n, t)$$

Define:

$$P_{sl}^Q(k, t) \equiv \left(\sum_{l' \in L} \sum_{n \in N_{sl'}(t)} p_{sl'}(n, t)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}} \quad (\text{C.5})$$

In this case we have:

$$\begin{aligned} y_s^C(k, t) &= \left(\frac{\sigma_s - 1}{\lambda \sigma_s} \right)^{\sigma_s} P_{sl}^Q(k, t)^{1-\sigma_s} \Rightarrow \left(\frac{\sigma_s - 1}{\lambda \sigma_s} \right)^{\sigma_s} = y_s^C(k, t) P_{sl}^Q(k, t)^{\sigma_s - 1} \\ &\Rightarrow q_{sl'}^*(n, t) = y_s^C(k, t) \left(P_{sl}^Q(t) / \delta_{sl'}(t) \right)^{\sigma_s(t)-1} p_{sl'}(n, t)^{-\sigma_s} \end{aligned} \quad (\text{C.6})$$

C2.2 Derivation of the Pricing Equation

If each firm faces a marginal cost c_s that is the same for all firms within a sector. The firms' profits satisfy:

$$\pi_{sl'}(n, t) \propto (p_{sl'}(n, t) - c_s) \sum_{l \in L} \sum_{k \in K} q_{sl'}^*(n, k, t) \cdot \sum_{\omega \in \Omega} \mathcal{I}_{(l, \omega)}(k, t) \quad (\text{C.7})$$

Here $\mathcal{I}_j(k, t)$ is the number of type k individuals in location-type pair $j = (l, \omega)$. Since there is a continuum of firms, each firm takes demand as a given. Hence, we can simply plug in the expression for the demand, impose the first-order condition, and solve for the optimal mill price, which yields:

$$\begin{aligned} \pi_{sl'}(n, t) &\propto (p_{sl'}(n, t) - c_s) p_{sl'}(n, t)^{-\sigma_s} \sum_{l \in L} \left(P_{sl}^Q(t) / \delta_{sl'}(t) \right)^{\sigma_s(t)-1} \sum_{k \in K} y_s^C(k, t) \mathcal{I}_l'(k, t), \\ \mathcal{I}_l'(k, t) &\equiv \sum_{\omega \in \Omega} \mathcal{I}_{(l, \omega)}(k, t) \end{aligned}$$

If there are enough firms that $\partial P_{sl}^Q(t) / \partial p_{sl'}(n, t) \approx 0$, then we have:

$$\begin{aligned} \frac{\partial \pi_{sl'}(n, t)}{\partial p_{sl'}(n, t)} &\propto (1 - \sigma_s) p_{sl'}(n, t)^{-\sigma_s} + c_s \sigma_s p_{sl'}(n, t)^{-\sigma_s - 1} = 0 \\ &\Leftrightarrow p_{sl'}^*(n, t) = c_s \frac{\sigma_s}{\sigma_s - 1} \equiv p_s^*(t) \end{aligned} \quad (\text{C.8})$$

That is, in this case all firms in sector s charge the same price at any given time, t , with the markup determined by the elasticity of substitution, σ_s .