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Essi Eerola
Tuukka Saarimaa

VATT INSTITUTE FOR ECONOMIC RESEARCH

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Valtion taloudellinen tutkimuskeskus
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Essi Eerola, Bank of Finland and CESifo, essi.eerola@bof.fi

Tuukka Saarimaa, VATT Institute for Economic Research,
tuukka.saarimaa@vatt.fi

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Abstract

This paper studies how much public housing generates rent savings for the tenants, how these savings are distributed among the tenants, and whether the tenants reside in better quality neighborhoods than similar low-income private rental tenants. Our rent savings estimates are based on a hedonic regression and detailed data on the private and public rental housing units from the city of Helsinki. We estimate that the total subsidy to public housing tenants is considerable and comparable in size to the housing allowance, the main tenant-based housing program. We also find that the subsidy is less targeted towards low-income households than the housing allowance. Regarding neighborhood quality, we find that public housing tenants live in lower quality neighborhoods than similar households living in private rental housing. This result suggests that public housing is not better than the housing allowance in delivering better neighborhood quality to low-income households.

Key words: Hedonic regression, housing policy, public housing

JEL classes: H22, R21, R23

1. Introduction

Housing programs that are directed towards reducing low-income households' housing costs can be divided into two broad categories: (1) project- or place-based programs, such as public rental housing or privately-owned subsidized rental housing; and (2) tenant-based programs, such as housing vouchers and allowances. Both types of programs are designed to generate rent savings for low-income households and thereby influence housing and non-housing consumption.

Place-based programs are often seen as problematic because the subsidy in the form of rent savings is by design targeted to specific geographic locations, i.e. a household benefits from the program only by residing in a specific building and neighborhood. This feature may result, for example, in high concentration of poor households in particular neighborhoods and buildings. On the other hand, the same feature also implies that the location of public housing and tenant selection can be used to promote desirable neighborhood social mix or to prevent harmful segregation.[1]

However, existing evidence on the degree to which different housing programs improve households' access to better neighborhoods is mixed.[2] In this paper, we analyze a large public housing program and contribute to the discussion on the relative merits of the different types of programs. We use detailed data on the private and public rental housing units and their tenants in the city of Helsinki. Our rental market data contain information about the attributes of the housing units including their exact location. We can merge the rental market data to household register data containing information on the tenants' socio-economic background and incomes.

Our analysis consists of two parts. In the first part, we study how much the public housing tenants benefit in terms of rent savings. We estimate this benefit by employing hedonic regression methods to recover implicit prices for different housing attributes within the private rental market where there are no restrictions on rent setting. We then

[1] Segregation is a natural phenomenon in an urban area with heterogeneous land quality and local amenities. Given that these amenities are normal goods, high-income households tend to outbid low-income households for better quality neighborhoods and households will sort into neighborhoods according to income (e.g. Bayer et al., 2007 and Bayer and McMillan, 2012). While natural, this tendency may also have harmful effects. Although the mechanisms creating neighborhood disadvantage are not well understood, there exists some evidence on the causal effects of neighborhoods on especially children's long-term outcomes. For more on this discussion, see e.g. Galster et al. (2008), Cheshire et al. (2008), Chetty et al. (2015) and Chetty and Hendren (2015).

[2] See e.g. Olsen (2009), Olsen and Zabel (2015) and Collinson et al. (2015) for further discussion.

use these implicit prices to predict market rents for the public housing units. This prediction reveals the rent that a particular public housing unit would command in the private market. The difference between the prediction and the actual rent allows us to determine the unit specific subsidy (or rent saving) and to analyze whether and how the subsidy depends on the physical attributes or the location of the unit. Finally, we combine the subsidy estimates with register data on households and compare the distributional effects of the program to those of a large tenant-based program (means-tested housing allowance).[3]

In addition to generating rent savings for low-income households, the public housing program explicitly aims at creating mixed-income neighborhoods and buildings. Thus, in the second part of the paper, we compare the neighborhood quality of low-income public housing tenants and similar households living in private rental housing. This comparison allows us to assess the ability of the public housing program to create mixed-income neighborhoods and to affect the exposure of low-income households to different neighborhood quality measures.

Our findings can be summarized as follows. We estimate that the total subsidy to households living in public housing units in Helsinki is considerable and amounts to 151 million Euros per year. The average annual subsidy to a public housing household is 4450 Euros. The total amount paid in housing allowances is somewhat larger, roughly at 166 million Euros, while the mean annual housing allowance to a recipient was 3840 Euros. The size of the public housing subsidy depends on the physical attributes of the unit and especially its location. The subsidy decreases substantially as the distance to the central business district (CBD) increases and is highest in expensive areas.[4]

[3] If the supply subsidies for social housing increase the overall stock of housing, an increase in social housing may lower the overall rental rate. Existing empirical evidence suggests that supply subsidies lead to substantial crowding out, especially in locations with inelastic supply, and therefore benefit little in terms of increased overall housing stock (e.g. Malpezzi and Vandell, 2002, Sinai and Waldfogel, 2005, Baum-Snow and Marion, 2009 and Eriksen and Rosenthal, 2010). However, it should be kept in mind that our rent saving estimates do not take into account any general equilibrium effects that would occur if the whole public housing program would be abolished.

[4] Burge (2011) studies the low-income housing tax credit (LIHTC) program in the U.S. and finds that the LIHTC is unlikely to lead to meaningful rent savings for the tenants. On the other hand, Le Blanc and Laferrère (2001) show that in France the rent savings for the tenants are non-negligible and tend to increase with city size and decrease with flat size. They also show that some 35% of the benefits go the richest half of the population, while only some 5% of housing allowances go to households in the richest half of the population. Both studies focus on privately-owned subsidized rental housing.

We also find that the distributional effects of the public housing subsidy and the housing allowance are quite different. The housing allowance is much more concentrated to low-income households than the public housing subsidy. The households in the lowest two income deciles receive 66% of the total amount of the housing allowance, but only 34% of the rent savings created by public housing. Moreover, 22% of the public housing subsidy goes to the top half of the income distribution.

When assessing the differences in neighborhood quality, we find that households with higher income levels tend to live in higher quality neighborhoods. This is true for both private rental housing and public housing. More importantly, however, we find that low-income households living in public housing are exposed to lower quality neighborhoods (measured either at the zip code or at the building level) than similar low-income households living in private rental units. All in all, our findings suggest that public housing is not better than the housing allowance in delivering better neighborhood quality to low-income households.

The rest of the paper is organized as follows: In the next section, we discuss the institutional details of the Finnish housing policy programs with special focus on the Helsinki housing market. We then present and discuss the data and describe our empirical strategy in determining the rent savings of public housing tenants. In section 4, we present our results on the distributional effects together with the effects on neighborhood quality. Section 5 concludes.

2. Institutional setting

In Finland, a large social housing sector co-exists with private rental market. Roughly 40% of all rental housing can be characterized as social housing owned either by municipalities (public housing) or non-profit organizations (privately-owned subsidized housing). In Helsinki, the share of social housing is slightly higher than the national average and roughly 70% of all the social housing units are public housing owned by the city of Helsinki.[5]

[5] These figures suggest that the social housing sector in Helsinki is quite large in European comparison (see, e.g. Scanlon, 2015).

The social housing program is managed by the Housing Finance and Development Centre of Finland (ARA), an off-budget government agency operating under the supervision of Ministry of Environment. The program covers both public housing and privately-owned subsidized housing. It dates from the mid 1940's and consists of different subsidy schemes for construction and renovation of rental housing. The details as well as the stated objectives have changed over time. Currently, the main objective is to provide affordable housing for low-income households.[6] In addition, the program aims at creating socially balanced neighborhoods and diversified buildings in terms of household composition.

The owners of social housing units receive subsidies from the municipalities (e.g. low lot rents) and the central government (e.g. interest-subsidy loans and state guarantees) and are subject different types of regulation. Most importantly, the rents are regulated for a certain period of time after construction (in most cases 40 years). During this time, the rent has to be based on capital and maintenance costs of the building.[7] As a result, there is no direct link between the private rental rate and rents in social housing. Instead, the rent difference between the two sectors depends on the local housing market conditions.

Tenant selection is based on legislation. The selection criteria include applicant's need for housing, financial situation and income.[8] However, in order to achieve the objective of socially balanced neighborhoods, a vacant public housing unit may also be allocated to a middle-income household. Once a household has obtained a social housing unit, it has the right to occupy the unit indefinitely, even if its income increases.

The other major housing program is the housing allowance program financed by the government through the Social Insurance Institution of Finland (KELA). The program consists of a general housing allowance and separate schemes for pensioners and students. In total, the housing allowance expenditures amounted to some 1.5 mrd Euros (or 0.75% of GDP) in 2014.

[6] However, part of the stock is explicitly directed towards special groups (the disabled, students and the elderly).

[7] The cost items that can be included in the rent are set by ARA.

[8] Each owner has its own application procedure. In the case of the city of Helsinki, the applicants do not apply for a specific flat, instead they specify in the application one or several neighborhoods from which they search for a flat. There is no explicit ranking of the applicants or a formal queuing system.

The housing allowance is means-tested and depends on the characteristics of the households (income and household size in particular) as well as on the rent (or housing costs) and characteristics of the dwelling (most importantly size). Eligibility does not depend on whether the household lives in private rental housing, social housing or owner-occupied housing, but 95% of the housing allowance recipients live in rental housing.

There is considerable overlap between the social housing program and the housing allowance program. For instance, roughly 10% of all households in Helsinki received general housing allowance in 2014 and half of the recipient households lived in public housing or privately-owned subsidized housing.

3. Predicting market rents and subsidy

3.1 Data sources

We use data from a number of sources. First, we use register data on households and their dwellings consisting of a 15% random sample of all households living in Helsinki from 2011. These data come from Statistics Finland. For each household, the data contain information about the physical attributes of the housing unit and location of the building. All the units can be classified as owner-occupied, public housing, privately-owned subsidized rental housing, or private rental housing. In addition, we have collected information on the rents of the public housing units from the city of Helsinki.[9] These rent data are not available for privately-owned subsidized rental housing. This means that we will not be able to estimate the rent savings for these tenants. Therefore, all the results on rent savings apply to public housing tenants only.

In order to predict the market rent of the public housing units in our data, we use data on private rental units collected from a commercial website (Vuokraovi.com), where landlords publish information about the units available for rent. All major institutional landlords use it as an advertising channel. The website covers the whole of Finland, but we only use information on units in Helsinki. We accessed the website on a

[9] Our data contain the average monthly rent per square meter in each public housing building (roughly 700 buildings in Helsinki). In some buildings, the rent per square meter is the same in all units. In others, it varies somewhat according to the size and the story of the unit.

weekly basis starting in May 2012 until the end of December 2013. Each observation contains detailed information about the unit including the address.

3.2 Hedonic regression

The first step in our analysis is to estimate the market rent of the public housing units. Because housing is a differentiated product, we need to have information on how different attributes of the units are priced in the private market. Table 1 reports descriptive statistics for the units in our private rental market sample and in our public housing data. The table shows that the average monthly rent per square meter in public housing is roughly half of the average rent in the private rental market.

However, the difference in the average rents would not be a good measure of the rent savings in public housing, because private rental units and public housing units differ also in other respects. Public housing units (in our sample) are on average larger, newer and situated farther away from the central business district (CBD) than private market units. These observations motivate the use of hedonic regression techniques in recovering reliable estimates of the rent savings of the public housing tenants.

Table 1. Descriptive statistics: housing units.

	Private rental market		Public housing	
	Mean	Std. Dev.	Mean	Std. Dev.
Observations	4,737		5,064	
Rent per m2	19.3	4.27	9.81	0.77
Floor area (m2)	55.5	20.6	59.7	17.5
Number of rooms	2.15	0.87	2.39	0.86
Age (years)	29.0	27.2	32.0	15.8
Balcony (0/1)	0.70	0.46	0.64	0.48
Sauna (0/1)	0.33	0.47	0.04	0.19
Distance to CBD (km)	6.89	3.40	8.36	2.75

Notes: The data on private rental units are from Vuokraovi.com. The public housing rent data are from the city of Helsinki and the public housing unit characteristics data are from Statistics Finland.

The map in Figure 1 further illustrates the spatial distribution of the public housing units in our data. The data on public housing are shown only for those zip code areas for which we also have rental data on private market units. The CBD is situated in the south-west peninsula.

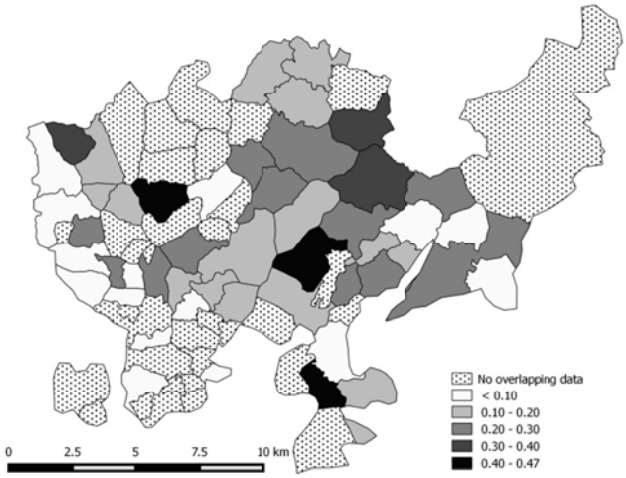

Figure 1. Share of public housing units by zip code.

Notes: The map includes data only from those zip codes where we have data on both private and public housing units.

The share of public housing units varies greatly from one neighborhood to another and there are hardly any public housing units in the zip code areas close to the CBD. As we move away from the CBD, the share of public housing units increases, but there are clear differences in the prevalence of public housing also further away from the CBD. The areas in northern Helsinki with no overlapping data have a high share of single detached houses.[10]

In a hedonic model, housing units are treated as differentiated products and hedonic regression is a way to estimate hedonic or implicit prices for different housing attributes. These implicit prices can be used to predict market rents for public housing units. The subsidy to a given public housing tenant in terms of rent savings can then be calculated as the difference between the predicted market rent from the hedonic regression and the actual rent of the unit.

We estimate the following hedonic rent regression:

$$(1) \qquad p_{ij} = \mathbf{x}_i'\boldsymbol{\beta} + \mu_j + u_{ij},$$

[10] The large zip code area in the north-east containing no public housing was annexed to Helsinki in 2009.

where p_{ij} is the monthly rent of a private market unit *i* in zip code *j*, **x** are the unit's physical attributes including distance to CBD, μ_j represent zip code area[11] fixed effects that capture unobservable location specific attributes, and *u* is the error term.

In the estimation, we need to worry about two distinct set of attributes, the physical attributes of the housing unit and the characteristics of the neighborhood. In principle, we could add variables describing the neighborhood characteristics in the regression equation in the same manner as the physical characteristics of the unit and hope that the remaining unobserved neighborhood characteristics are a minor problem. However, a more reliable approach is to use spatial fixed effects (μ_j), which enable modelling the effect of different location attributes without having to include them separately into the model. This is useful in our setting, because we are not interested in estimating the effect of various neighborhood characteristics on rents.

In addition to unobservable neighborhood attributes, we need to worry about unobservable unit attributes, most importantly the condition of the unit. There may exist differences in the condition of the units in the two sectors as landlords in the private rental market are likely to have stronger incentives to maintain and improve the condition of their units than public housing landlords. This is a potential problem because the difference in the predicted market rent and the actual rent for the public housing units can arise from this omitted variable.

With these caveats in mind, we define the unit specific rent saving or the public housing subsidy for public housing unit *k* as

$$(2) \qquad subsidy_k = \hat{p}_k - p_k^{sub},$$

where $\hat{p}_k$ is the out-of-sample prediction from Eq. (1) for unit *k* and p_k^{sub} is the unit's actual rent. Of course, the accuracy of our subsidy estimate relies on the reliability of our market rent prediction. In order to be able to assess our prediction, we draw from the private rental market data a 10% random sample which we do not use in the estimation. We then predict the market rent and calculate a prediction error for each

[11] Helsinki is divided into some 80 zip codes with an average size of roughly 7,000 inhabitants. In our data, there are public housing units in 45 zip code areas. In the estimation, we use private market data only from these areas.

private rental unit in the sample. On average, this out-of-sample prediction error should be zero and it should not vary systematically with unit attributes.

3.3 Determinants of the subsidy

Figure 2 shows the distribution of the public housing subsidy based on Eq. (2) and the distribution of the out-of-sample prediction error for the private rental housing units not used in the estimation. The average monthly subsidy in public housing is about 370 Euros per unit or 6.7 Euros per square meter. The distribution of the estimated subsidy for the public housing units is clearly different from the prediction error for the out-of-sample private market units. The average subsidy is zero for the private rental housing. However, Figure 2 also clearly shows that there is substantial variation in the out-of-sample prediction error for the private market units. This is to be expected as we do not observe all the characteristics of the units that potentially influence the rents. There are also a couple large outliers among the private rental units for which we substantially underestimate the rent level as can be seen from Panel A. This variation should be kept in mind when interpreting the results.

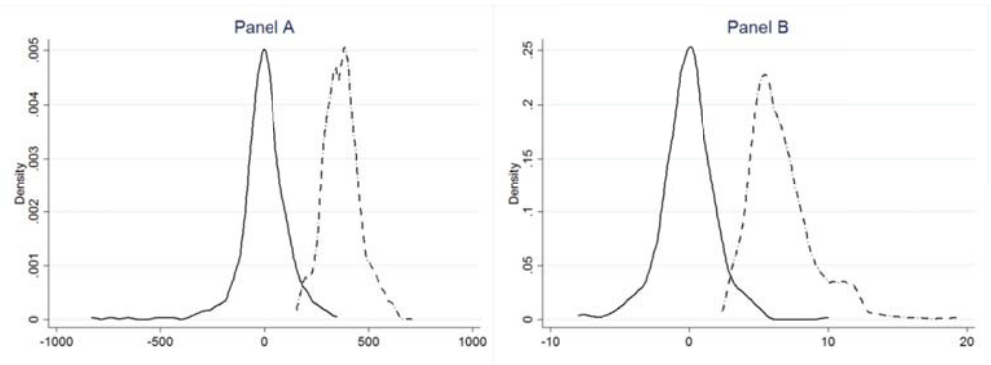

Figure 2. Distributions of public housing subsidy and prediction error for private units.
Notes: Panel A depicts the monthly subsidy (€) and Panel B the monthly subsidy per square meter (€/m^2).

In Table 2, we analyze the prediction error in more detail. In column (1), we present regression results on the out-of-sample prediction error. In the regression, we explain the unit specific prediction error (left panel of Figure 2) using the same unit characteristics and zip code fixed effects as in Eq. (1). Reassuringly, none of the physical attributes of the hedonic regression can explain the prediction error in the out-of-sample units. Also, only one out of the 44 zip code fixed effects is statistically

significant at 5% level. This means that there is no systematic bias in our prediction. As a result, although there is a lot of measurement error in our rent prediction, we are not systematically overestimating the rent savings for, say, large units or units in certain locations.

Finally, we analyze more closely the determinants of the subsidy. Because dwellings are differentiated products, the price differences between private and public rental units can arise from the way physical attributes or location are priced. In columns (2) and (3) of Table 2 we present the results from two hedonic regressions. Column (2) presents the results from the regression that we used to predict market rents. Column (3) presents the results for the same model specification, but using the public housing units.

As can be seen from columns (2) and (3), the differences in the implicit prices of physical attributes partly explain the size of the subsidy of a given public housing unit. The price differences are mostly related to the floor plan (number of rooms conditional of floor area) and age of the units. Furthermore, unit attributes and zip code fixed effects explain a larger share of the total variation in rents in the public housing sample compared to the private market sample. Of course the coefficients reported in column (3) do not contain information about households' marginal willingness to pay for unit attributes, but instead they simply reflect the pricing schedule of the city.

Table 2. Hedonic regression results.

	Prediction error for private units	Private units	Public units
	(1)	(2)	(3)
Constant	55.10	739.9***	208.5***
	(74.67)	(60.67)	(29.51)
Floor area	4.807	8.987***	9.109***
	(3.723)	(1.601)	(0.646)
(Floor area)^2	-0.041	0.011	0.007
	(0.031)	(0.011)	(0.006)
Age	0.603	-4.666***	-5.456***
	(2.282)	(1.075)	(0.906)
Age^2	-0.025	0.044	0.086***
	(0.057)	(0.028)	(0.024)
Age^3	0.00006	-0.00003	-0.0004***
	(0.0003)	(0.0002)	(0.0002)
2 rooms (ref. 1 room)	-42.95*	23.95**	-0.908
	(24.99)	(11.67)	(3.611)
3 rooms	-8.699	60.99***	-4.494
	(31.48)	(13.49)	(5.115)
4 rooms or more	-37.83	89.41***	-12.17
	(58.32)	(24.17)	(9.217)
Sauna (0/1)	-1.115	57.72***	1.251
	(20.37)	(12.49)	(6.734)
Balcony (0/1)	-13.22	-10.08	-3.266
	(26.11)	(10.64)	(2.634)
Distance to CBD	-25.16	-9.650	-2.891
	(24.05)	(8.321)	(7.243)
N	473	4,264	5,064
R^2	0.17	0.87	0.98

Notes: The table reports results from OLS regressions using housing unit level data. All the models include zip code level fixed effects.

In addition to the implicit prices of physical attributes of the unit, the subsidy can arise from differences in the price of location. In Figure 3, we plot the subsidy as a function of distance to the CBD (or the Helsinki central railway station). As the figure shows, the monthly subsidy to a given housing unit decreases as the distance to the CBD increases. The same pattern arises if we measure the monthly subsidy per square meter. [12]

[12] This relationship does not show up in Table 2 because of the zip code fixed effects.

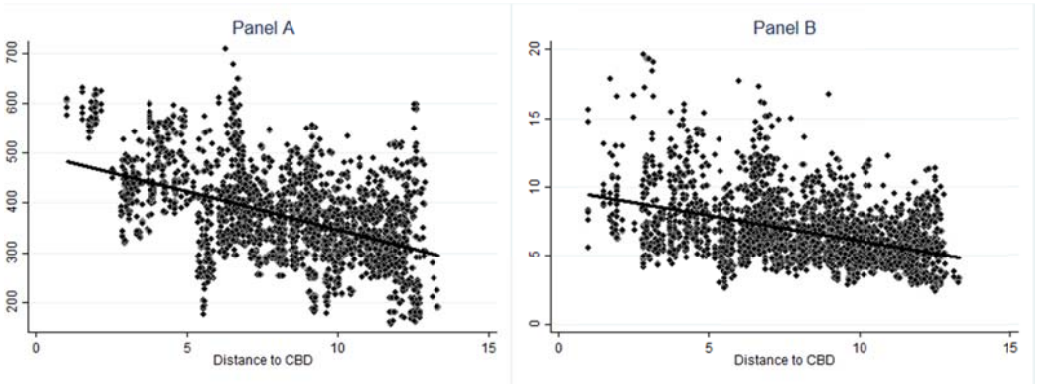

Figure 3. Public housing subsidy according to distance to CBD.

Notes: Panel A depicts the monthly subsidy (€) and Panel B the monthly subsidy per square meter (€/m^2).

Figure 3 also shows that there is a lot of variation in the subsidy within a given distance. This is to be expected as locations differ in a number of other dimensions besides their distance to the CBD. In Figure 4, we illustrate these differences using a zip code map. The upper map shows the average market rent per square meter in the different zip codes. As the map shows, there is a lot if variation in market rents between the zip codes and most of the expensive neighborhoods are located close to the CBD (south-west peninsula). The lower map shows that the largest subsidies per square meter accrue to the units close to the CBD and other zip codes with relatively high market rents. Figure 4 also illustrates that public housing units are not situated in the most expensive neighborhoods.

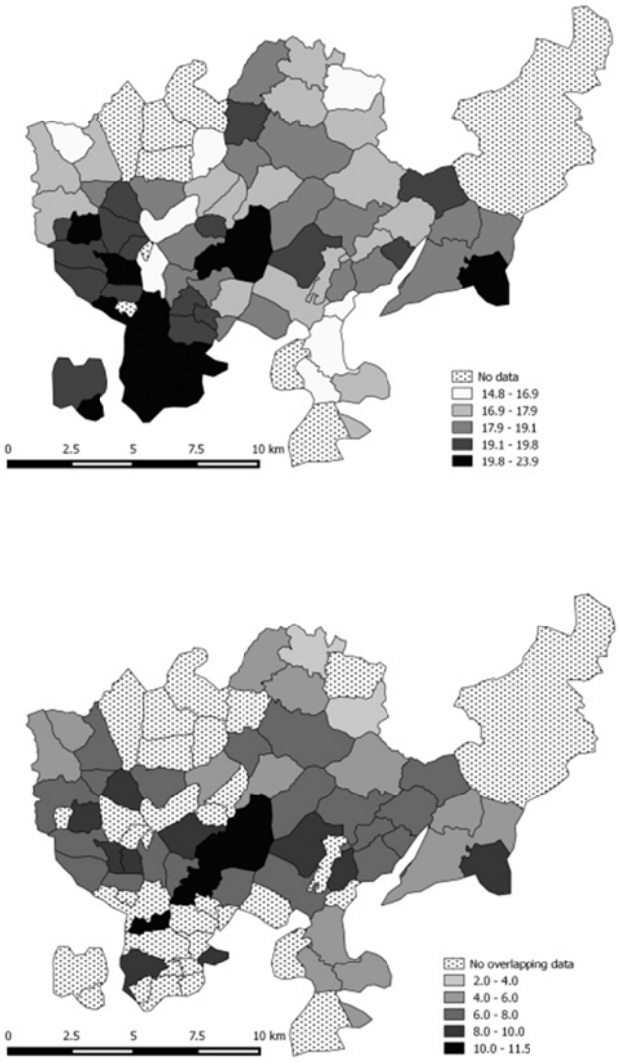

Figure 4. Market rents (upper map) and public housing subsidy (lower map) by zip code (€/m^2/month).

It should be kept in mind that regional variation in the size of the subsidy does not necessarily mean that the system is poorly designed. Instead, variation may be necessary in order to influence the neighborhood social mix. Next, we turn to the issue of what type of households benefit from the public housing subsidy and whether the program succeeds in promoting mixed-income neighborhoods.

4. Household analysis

4.1 Distribution of public housing subsidy

In this section, we link our estimates of the unit specific subsidies to the characteristics of the tenants. Table 3 shows descriptive statistics of owner-occupiers, private rental housing tenants and public housing tenants in our data.

The public housing tenants have on average lower incomes than those in private rental housing. The renters in the two segments are also different in other respects: Households in public housing tend to be less educated, larger and have more often small children. Out of all public housing tenants, some 23% also receive housing allowances, while the share of housing allowance recipients is 13% among the private rental housing tenants and only 2% among the owner-occupiers. The average allowance is higher in public housing than in private rental housing. This difference can be explained by public housing tenants having more often small children and living in larger units.[13]

Table 3. Descriptive statistics: households.

	Homeowners		Private rental		Public housing	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Observations	21,934		10,915		5,354	
Age of household head	54.1	17.0	40.1	16.4	48.5	16.6
Disposable income (€/year)	34,659	47,877	22,953	19,685	18,519	8,206
Master's degree	0.27	0.45	0.16	0.36	0.04	0.19
Household size	1.93	1.10	1.49	0.85	1.94	1.26
Household with children	0.10	0.30	0.07	0.25	0.13	0.34
Housing allowance recipient	0.02	0.13	0.13	0.33	0.23	0.42
Housing allowance (€/year)	2,775	2,307	3,521	2,601	4,321	2,567
Public housing subsidy (€/year)					4,449	1,033

Notes: The mean housing allowance is calculated over households that received housing allowance. Disposable income includes the housing allowance, but does not include the public housing subsidy

[13] Differences in rents per square meter are unlikely to account for the differences in the average housing allowance in the two sectors because of a ceiling in the rent per square meter. Market rents per square meter in Helsinki tend to be well above the ceiling. When the rent per square meter is higher than the ceiling, the part exceeding the ceiling is ignored when calculating the housing allowance. This ceiling was abolished in 2015 when the housing allowance was reformed.

In order to study the distributional effects of the public housing subsidy, we divide households into income deciles based on their disposable income.[14] Panel A of Figure 5 presents the shares of different tenure status (owner-occupied, private rental housing, public housing and privately-owned subsidized housing) in the different income deciles. Two interesting observations stand out. First, in the lowest deciles, private rental housing is more common than social housing (public housing and privately-owned subsidized housing combined). For example, in the lowest decile, more than 40% of the households live in private rental housing while only roughly 20% lives in public housing or privately-owned subsidized housing. Second, both public housing and privately-owned subsidized housing extend well beyond the lowest deciles.

Panel B of Figure 5 shows the distribution of the public housing subsidy in each income decile. For comparison, the figure also reports the housing allowance in each decile.[15] For each decile, the figure shows the share of total public housing subsidy and total housing allowance. Recall that eligibility for housing allowance depends on household income and composition, but not on tenure. That is, renters in different sectors (public housing, privately-owned subsidized housing and private rental housing) as well as owner-occupiers can all be housing allowance recipients.

The distributions of these two benefits are quite different. The households in the lowest two deciles receive some 66% of the total amount of the housing allowance, but only 34% of the rent savings created by public housing. Therefore, the public housing subsidy is clearly less targeted towards the low-income households than the housing allowance. Moreover, 22% of the public housing subsidy goes to the top half of the income distribution.

[14] We scale the household income using the OECD equivalence scale which assigns value 1 to the first adult household member, 0.7 to each additional adult and 0.5 to each child.

[15] The housing allowance includes both the general housing allowance and the pensioners' housing allowance. We exclude all students that receive the students' housing allowance and also students who live in public housing. These public housing units are typically shared apartments.

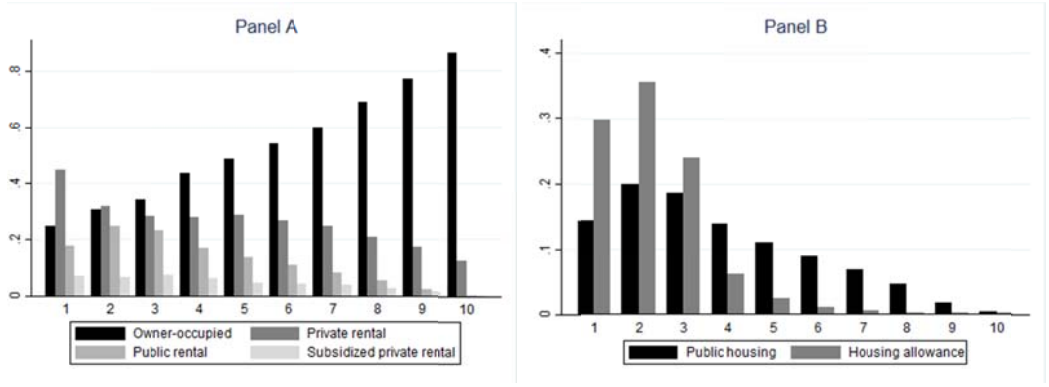

Figure 5. Housing tenure and distribution of subsidy by income decile.

Notes: The income deciles are based on disposable income scaled by the OECD equivalence scale. Panel A describes the tenure structure of each income decile. Panel B describes the shares of the total public housing subsidy and the housing allowance received by households in each income decile.

In Table 4, we look more closely at the households in different parts of the income distribution.[16] For the table, we have divided the households into quintiles, because there are so few public housing tenants and especially housing allowance recipients in the top income deciles. The average public housing subsidy and also the subsidy per square meter are quite similar across the income quintiles (Panel B). Table 4 reinforces the message from Figure 5 that middle-income and even some high-income households receive substantial rent savings through the public housing program.

Private rental tenants are on average smaller and live in smaller units than public housing households across the quintiles. This means that the public housing subsidy is more directed towards families, whereas the private rental tenants that receive the housing allowance are more likely to be single households. It is also interesting to note that the public housing tenants in the lowest income quintile receive more housing related subsidies than private rental tenants. For instance, the private rental tenants in the first income quintile receive on average 2,562 Euros in housing allowances. However, public housing tenants in the same income quintile benefit on average 3,471 Euros in terms of rent savings and receive on average 2,764 in housing allowances

[16] We do not consider tenants of privately-owned subsidized rental housing here because we do not have an estimate of the rent savings for them.

Table 4. Household characteristics by income quintile.

	I	II	III	IV	V
Panel A: All households					
Number of households	8,341	8,340	8,341	8,340	8,340
Disposable income (€/year)	10,782	17,635	23,603	30,785	58,652
Household size	1.54	1.66	1.80	1.96	2.07
Mean floor area (m^2)	48.5	55.8	59.9	66.9	86.1
Housing allowance (€/year)	2,581	2,115	1,661	1,271	1,088
Panel B: Public housing tenants					
Number of households	1,861	1,775	1,079	610	111
Disposable income (€/year)	11,719	17,371	23,383	30,163	43,468
Household size	2.01	1.88	1.94	1.96	1.96
Mean floor area (m^2)	57.2	60.4	61.1	62.4	66.1
Housing allowance (€/year)	2,764	2,112	1,934	1,321	-
Public housing subsidy (€/year)	3,471	3,497	3,448	3,374	3,296
Public housing subsidy (€/m^2/month)	7.06	6.49	6.57	6.52	6.27
Panel C: Private rental tenants					
Number of households	3,156	2,325	2,296	1,895	1,243
Disposable income (€/year)	10,085	17,621	23,550	30,525	52,948
Household size	1.34	1.45	1.48	1.63	1.79
Mean floor area (m^2)	38.9	43.1	44.9	50.9	66.4
Housing allowance (€/year)	2,562	2,123	1,615	1,238	-

Notes: The income quintiles are based on disposable income scaled by the OECD equivalence scale. All the numbers represent quantile means in the household groups. The annual means of disposable household income, the housing allowance and the public housing subsidy are scaled by the OECD equivalence scale. The mean housing allowance is calculated over households that received housing allowance. Disposable income includes the housing allowance, but does not include the public housing subsidy.

4.2 Public housing subsidy and neighborhood quality

By reducing the price of housing relative to other consumption, both tenant-based and project-based policies can affect the location choices of low-income households. Due to the lower price of housing, households can either increase other consumption or increase housing consumption by moving to a larger unit or to a better quality neighborhood. Therefore, both tenant-based and project-based programs may influence the neighborhood quality of low-income households.[17]

However, project-based programs can also be used to influence who lives next to a low-income household. Targeting a fraction of the public housing subsidy towards

[17] Carlson et al. (2012) review the evidence on the effects of tenant-based programs on households' relocation decisions.

middle-income and high-income households can, therefore, be motivated by the aim of creating mixed-income neighborhoods and buildings.[18]

Within the Finnish program, the creation of mixed-income neighborhoods and buildings can happen through building location, tenant selection or through the unlimited right to occupy the public housing unit once obtained. In this section, we evaluate whether the program is successful in achieving this aim.[19] More specifically, we will ask whether low-income public housing tenants are exposed to better quality neighborhoods than similar low-income households living in private rental units.

We use zip code areas and buildings to define a neighborhood and consider four neighborhood quality measures: the median disposable income, the share of households under the local poverty line (defined as having less than 60% of the median income in Helsinki), the share of households with a master's degree and the rental rate in private rental housing. The first three measures are directly related to the characteristics of the neighbors that the low-income households are exposed to. The last measure aims at capturing neighborhood amenities that capitalize into rental rates.

Our strategy is to compare the exposure of public housing tenants and private rental tenants to different neighborhood characteristics by income quintile using the following regression model:

$$(3) \qquad Y_i = \alpha + \sum_{j=2}^{5} \alpha_j I_{j,i} + \sum_{j=1}^{5} \gamma_j \left(P_i \times I_{j,i} \right) + \mathbf{z}_i' \boldsymbol{\beta} + \varepsilon_i,$$

where Y is a measure of neighborhood (or building) quality, P is a dummy variable indicating public housing tenancy, I is an indicator function taking value one if household i belongs to income quintile j and zero otherwise, $\mathbf{z}$ is a vector of household characteristics and ε is the error term. It is important to control for household characteristics as the private rental and public housing tenants differ in a number of respects (see Table 4).

[18] For example, Leung at al. (2012) argue using a general equilibrium sorting model that the location of public housing units is a fundamental policy variable when it comes to influencing low-income households' access to local public goods.

[19] For a discussion on similar policies, see Collinson et al. (2015).

Table 5 reports the estimation results for the zip code area level using a sample of only private rental tenants and public housing tenants.[20] As expected, private rental housing tenants in higher income quantiles tend to live in neighborhoods with higher median income, less poverty, higher education level and higher market rents. All in all, the results indicate residential sorting according to income.

Two results stand out from Table 5 concerning public housing tenants. First, the public housing tenants in the lowest income quintile live in lower quality neighborhoods than similar private rental tenants in the same quintile. They live in neighborhoods with some 2,400 Euros or 10% lower median income than similar low-income households in private rental housing. In other words, low-income public housing tenants live in less diversified neighborhoods than private rental tenants. They also live in neighborhoods with a lower share of households with a master's degree (roughly 8 percentage points) and a lower rental level in the private rental housing (roughly 2.4 Euros per square meter) indicating lower levels of neighborhood amenities.[21]

Second, the pattern across income quintiles in the public housing sector is quite similar to that in the private market. Public housing tenants higher up in the income distribution live in better quality neighborhoods than the ones in the lowest income quintile. In fact, the public housing tenants in the second and third income quintile live in similar zip codes as the private rental tenants in the same income quintile. However, the comparison between the public housing tenants and private rental housing tenants in the fourth and fifth income quintile indicates that the public housing tenants live in zip codes with lower median income (by 1,451 Euros) and lower share of households with a master's degree (by 3.6 percentage points).

[20] We include only those zip codes that have at least 20 households in our data. The number of households in our sample in these zip codes ranges from 29 to 1736.

[21] It is possible that private rental market tenants and public housing tenants in the first income quintile are different even if we control for household characteristics. An alternative way to control for underlying differences is to focus on those low-income households that are housing allowance recipients each month of the year. When doing so, we obtain the same results: housing allowance recipients in public housing live in neighborhoods with lower median income, lower share of people with a master's degree and lower market rents than similar housing allowance recipients in private rental market.

Table 5. Neighborhood exposure at zip code level.

	Median income	Poverty rate	Share with a master's degree	Mean rent (€/m^2)
	(1)	(2)	(3)	(4)
Constant	23397***	0.199***	0.206***	20.90***
	(613.0)	(0.011)	(0.015)	(0.606)
2. quantile	54.18	-0.004**	0.002	0.051
	(122.7)	(0.002)	(0.004)	(0.142)
3. quantile	683.9***	-0.011***	0.016***	0.326*
	(171.8)	(0.002)	(0.004)	(0.170)
4. quantile	1315***	-0.016***	0.034***	0.761***
	(263.0)	(0.004)	(0.006)	(0.249)
5. quantile	2622***	-0.029***	0.066***	1.370***
	(400.6)	(0.005)	(0.010)	(0.342)
1. quantile * public tenant	-2392***	0.014*	-0.076***	-2.407***
	(476.6)	(0.008)	(0.013)	(0.509)
2. quantile * public tenant	94.71	-0.000	0.003	0.029
	(145.0)	(0.003)	(0.004)	(0.168)
3. quantile * public tenant	-253.6	0.002	-0.004	-0.259
	(212.7)	(0.003)	(0.006)	(0.199)
4. quantile * public tenant	-742.81*	0.007	-0.019**	-0.456
	(319.5)	(0.005)	(0.008)	(0.306)
5. quantile * public tenant	-1451**	0.011	-0.036**	-0.764*
	(565.5)	(0.008)	(0.014)	(0.412)
N	14,534	14,534	14,534	14,412
R^2	0.20	0.08	0.24	0.24
Household controls	yes	yes	yes	yes

Notes: The table reports results from OLS regressions using household level data where the outcome variables are measured at the zip code level. The sample includes only renter households and those zip codes that have at least 20 households in our data. The household level control variables include the age of household head, an indicator whether the household has small children, an indicator whether the household is single and the number of persons in the household. Standard errors are clustered at the zip code level and are reported in the parentheses. ***, ** and * indicate statistical significance at 1, 5 and 10 percent level, respectively.

There are at least three potential explanations for this sorting by income pattern in the public housing segment. First, the rental rate in public housing units tends to be higher close to the CBD, although the rent differences between neighborhoods are much less pronounced than in the private rental market. Second, since the rent savings tend to be larger in attractive neighborhoods, the lock-in effects should be larger in these neighborhoods. This means that public housing tenants in attractive neighborhoods may be less likely to move when their income increases. Finally, the public housing units in

attractive neighborhoods may become vacant less frequently than other units. If so, low-income households may not be able to afford to wait for such a unit and are therefore not selected into attractive locations.[22] However, because the number of public housing tenants especially in the fifth quintile is quite small (see Panel B of Fig. 5), the figures should be interpreted with some caution.

The neighborhood characteristics to which low-income public housing tenants are exposed to are naturally at least partly driven by the location of the public housing buildings and hence composition of private rental tenants and owner-occupiers in the neighborhoods. It is therefore possible that the pattern we observe at the zip code level is due to the location of buildings. The same is not true at the building level. In principle, at least, the characteristics of the residents in a given public housing building can be directly influenced by tenant selection. In order to see whether this happens, we report in Table 6 the results of the neighborhood exposure estimation at the building level.[23]

The results are quite similar to those in Table 5. Low-income public housing tenants (the first income quintile) live in buildings with a lower median income, a higher share of households below the city level poverty threshold, and a lower education level than similar low-income households in private rental housing. In fact, the differences to exposure between these two household groups are larger at the building level than at the zip code level.[24] This suggests again that allocating some of the public housing units to middle-income and high-income households does not guarantee that the low-income public housing tenants live in buildings with a more diverse residential structure than similar low-income households.

There are various potential explanations for why the low-income private rental tenants live in buildings with more diverse residential structure. The results may be related to tenant selection and differences in the strength of the lock-in effects in the same manner as at the zip code level. In addition, one potentially important issue is that

[22] We do not observe the length of stay in current house in the data. We also do not have information about the tenant selection. Therefore, we cannot assess the importance of these different explanations.

[23] We do not consider the average rental rate because it does not have the similar interpretation at the building level as at the zip code level.

[24] We estimated these models using only those households who received the housing allowance in each month of the year. The results are similar.

private rental housing tenants often live in the same buildings with owner-occupiers. Because owner-occupied households have on average higher income levels these mixed-tenure buildings tend to be more mixed-income than those that are reserved for rental use only. Although we are not able to assess the relative importance of these explanations in driving the results of Table 6, it seems nevertheless far from obvious that public housing works better in delivering mixed-income buildings than tenant-based alternatives.

Table 6. Neighborhood exposure at building level.

	Median income	Poverty rate	Share with a master's degree
	(1)	(2)	(3)
Constant	20320***	0.319***	0.191***
	(687.5)	(0.027)	(0.017)
2. quantile	799.1***	-0.078***	0.001
	(263.5)	(0.011)	(0.008)
3. quantile	2434***	-0.109***	0.006
	(305.1)	(0.011)	(0.009)
4. quantile	4899***	-0.136***	0.059***
	(599.4)	(0.018)	(0.011)
5. quantile	5913***	-0.149***	0.093***
	(747.6)	(0.020)	(0.014)
1. quantile * public tenant	-4139***	0.083***	-0.122***
	(482.0)	(0.022)	(0.010)
2. quantile * public tenant	515.5	-0.027	0.004
	(390.4)	(0.020)	(0.009)
3. quantile * public tenant	-514.2	-0.005	-0.001
	(512.1)	(0.024)	(0.010)
4. quantile * public tenant	-2863***	0.033	-0.060***
	(853.4)	(0.034)	(0.013)
5. quantile * public tenant	-2896**	0.044	-0.087***
	(1198)	(0.045)	(0.020)
N	3,343	3,343	3,343
R^2	0.35	0.20	0.34
Household controls	yes	yes	yes

Notes: The table reports results from OLS regressions using household level data where the outcome variables are measured at the building level. The sample includes only those buildings that have at least 10 households in our data. The household level control variables include the age of household head, an indicator whether the household has children, an indicator whether the household is single and the number of persons in the household. Standard errors are clustered at the zip code level and are reported in the parentheses. ***, ** and * indicate statistical significance at 1, 5 and 10 percent level, respectively.

The results reported in Tables 5 and 6 are qualitatively similar to the results found in the U.S. For example, Horn et al. (2014) find that in the U.S. housing voucher holders live near better schools than public housing tenants, whereas Lens et al. (2011) find that voucher holders live in safer neighborhoods (in terms of crime) than public housing tenants.[25] These similarities suggest that it is difficult to design place-based housing subsidy programs so that poor tenants would not end up in poorer quality neighborhoods than households that receive tenant-based subsidies. This is true even in Helsinki where the social mixing has been a stated goal of the program throughout its history. Nonetheless, the details of the program design are important when assessing and comparing the effects of public housing programs. These details include the location of the public housing units, tenant selection rules and the rent level compared to private rental housing.

5 Conclusions

In this paper, we analyzed the effects of a large public housing program in Finland. In the first part of this paper, we used hedonic regression to analyze whether public housing units have lower rents than comparable private rental units. We estimate that the total rent savings or subsidy to households living in public housing units in Helsinki is considerable and comparable in size to the housing allowance, which is the main tenant-based housing subsidy program. At the housing unit level, the size of the public housing subsidy depends on the physical attributes of the unit and especially its location. The subsidy decreases substantially as the distance to the CBD increases. In addition, when comparing the distribution of the public housing subsidy to that of the housing allowance, we find that the public housing subsidy is clearly less targeted towards low-income households.

In the second part of the paper, we studied whether the public housing program is able to create socio-economically mixed neighborhoods and buildings. Our results indicate that the low-income public housing tenants live in lower quality neighborhoods and buildings than similar private rental housing tenants in the same income quintile.

[25] These studies also report racial differences with respect to these results.

This result holds both at a neighborhood level (zip code areas) and at the building level and is consistent across different measures of neighborhood quality. These results suggest that public housing is not better than the housing allowance in delivering better quality and more diversified neighborhoods to low-income households.

Several important questions remain unanswered. Perhaps the most important questions are related to the effects of a major reform or elimination of the program. Our estimates of the public housing subsidy are not directly useful when evaluating such reforms. Because the public housing sector constitutes a large share of all rental housing in Helsinki, a large reform would result in a new sorting equilibrium with new equilibrium housing prices (see e.g. Bayer and McMillan, 2012). Therefore, such policy changes cannot be evaluated without taking into account general equilibrium effects.

In order to have a more complete picture of the welfare effects of the program, it would also be useful to know more about who is selected into the public housing units and who moves out. The first question is related to the degree of potential misallocation of units when allocation involves rationing (see e.g. Early, 2000 and Glaeser and Luttmer, 2003). The second is related to the lock-in effects caused by public housing following from the fact that the subsidy received is tied to specific housing units (see e.g. Lui and Suen, 2011). These issues are left for future work.

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