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6674
2017

September 2017

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CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
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Editors: Clemens Fuest, Oliver Falck, Jasmin Gröschl
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CESifo *Working Paper No. 6674*
Category 1: Public Finance

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Abstract

This paper analyzes the relative merits of large place- and tenant-based housing programs in Finland in terms of housing affordability and neighborhood quality. Using hedonic regression methods and household micro data, we find that rent savings to public housing tenants are less targeted towards low-income households than housing allowance. In addition, low-income public housing tenants live in poorer, less educated and lower quality neighborhoods than similar low-income households in private rental housing. This suggests that place-based programs may lead to more segregation than tenant-based alternatives even when neighborhood mixing is an explicit aim of the program, as in Finland.

JEL-Codes: H220, R210, R230.

Keywords: hedonic regression, housing allowance, place-based policy, public housing.

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This version: September 2017

1. Introduction

Housing policy programs are typically intended to make housing more affordable for low-income households and to influence their housing and non-housing consumption. These programs can be divided into two broad categories: (1) tenant-based programs, such as housing vouchers and housing allowances or benefits; and (2) project- or place-based programs, such as public rental housing or privately-owned subsidized rental housing.

Place-based programs are often considered problematic because the subsidy in the form of rent savings is tied to the buildings and is thereby by design targeted to specific geographic locations. This may lead to high concentration of poor households in particular neighborhoods and buildings, which has been shown to have negative effects in certain contexts. On the other hand, it may be possible to mitigate this concentration by locating the buildings to sought-after neighborhoods and by applying tenant selection rules that allow middle- and even high-income households to occupy the units.[1]

In this paper, we contribute to the discussion on the relative merits of place- and tenant-based programs by analyzing a large public housing program in Finland and by comparing it to the housing allowance program. We focus on the capital city Helsinki where the city owns a large number of public housing units. The rents of these units are cost-based and regulated so as to make them more affordable than units in the private uncontrolled rental market. The program also explicitly aims at preventing the spatial concentration of poor households by scattering the buildings across neighborhoods and by allowing also relatively well-off households to occupy a public housing unit.

In the first part of the paper, we ask what type of households benefit and by how much from the rent savings generated by the public housing program. We define the rent savings as the difference between the rent a public housing unit would command in the private rental market and its actual regulated rent. The rent savings estimates are not trivial to come by because public housing units differ from private rental units with respect to location and physical attributes. To overcome this problem, we use detailed micro data on the attributes, rents and the location of private and public rental housing

[1] In general, segregation is a natural phenomenon in an urban area with heterogeneous local public goods and amenities. Given that these are normal goods, high-income households tend to outbid low-income households for better quality neighborhoods leading to neighborhood sorting according to income (see e.g. Cheshire and Sheppard, 2004 and Bayer et al., 2007).

units in Helsinki. Using hedonic regression methods with spatial fixed effects, we recover implicit prices for housing attributes within the private rental market where the rents are unregulated. We then use these implicit prices along with the estimates for spatial fixed effects to predict market rents and to calculate rent savings for individual public housing units. Finally, we match these unit level rent savings to household level register data, which allows us to compare the distributional effects of the rent savings created by the public housing and the means-tested housing allowance programs.

In the second part of the paper, we ask whether the public housing program is successful in preventing segregation and how the program compares to the tenant-based alternative in this respect. We answer these questions by comparing the socio-economic mix and quality of the neighborhoods of 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 affect the socio-economic mix of neighborhoods and especially the exposure of low-income households to different neighborhood characteristics.

Our findings can be summarized as follows. We estimate that the rent savings to public housing tenants are considerable and comparable in size to the housing allowance. The size of this public housing subsidy depends on the physical attributes of the unit, and it decreases with distance to the central business district (CBD) and is highest in expensive neighborhoods.

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

As discussed above, allocating part of the public housing subsidy toward middle- and high-income households may prevent spatial concentration of poor households. Our analysis of the neighborhoods that public housing tenants occupy suggests that this strategy does not work as intended. We find that low-income public housing tenants are exposed to poorer, less educated and lower quality neighborhoods (measured either at the zip code or at the building level) than similar low-income households living in private rental units. This finding suggests that public housing programs may lead to

more segregation than tenant-based alternatives even when neighborhood mixing is an explicit aim of the program.

It is important to note that when comparing the programs we ignore their general equilibrium effects in the housing market. 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. Early, 2000 and Bayer and McMillan, 2012 and Geyer, 2017). Therefore, our results are not directly useful when evaluating major reforms to current programs. We are also unable to relate the direct benefits to the administrative costs of the programs.[2]

2. Related literature

Our study contributes to the large literature evaluating housing policy programs. In this section, we review this literature focusing on research most related to our paper. The current literature is somewhat tilted toward U.S. policy programs, and a comprehensive summary of the U.S. experience can be found in Collinson et al. (2016) and Olsen and Zabel (2015).

Our study is closely related to papers that estimate the rent savings in public or privately-owned subsidized housing. Le Blanc and Laferrère (2001) show that in France the rent savings for public housing tenants are substantial and tend to increase with city size and decrease with unit size. They also conclude that the gains are less concentrated on the poorest part of the population than those of tenant-based housing subsidies. Similarly, Kattenberg and Hassink (2017) show that in the Netherlands the rent savings for social housing tenants are on average equal to almost 40% of the market rent and are higher in municipalities with high house values and little social housing. Burge (2011) in turn analyzes the low-income housing tax credit (LIHTC) program in the U.S. and finds that rent savings are sizable, but at the same time constitute a relatively small fraction of the programs costs.

Our paper is also related to the literature studying the quality and socio-economic mix of the neighborhoods that low-income households occupy. For the U.S., the general

[2] Two recent surveys in Collinson et al. (2016) and Olsen and Zabel (2015) conclude that in the U.S. place-based programs seem to have greater cost than tenant-based programs in providing equally good housing in equally desirable neighborhoods. We are unaware of evidence on this issue from European countries.

finding is that on average public housing tenants live in worse quality and poorer neighborhoods than housing voucher holders (Olsen and Zabel, 2015). For example, Horn et al. (2014) find that the 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 and LIHTC tenants. Susin (2005) and Lens et al. (2011) report similar results with respect to neighborhood poverty rate.[3]

Collinson and Ganong (2017) study the effects of the voucher program using a reform in Dallas. They find that a policy that indexes rent ceilings to neighborhood rents, instead of metro-level rents, leads voucher holders to move in higher-quality neighborhoods with lower crime, poverty and unemployment. Carlson et al. (2012) review the earlier evidence on the effects of tenant-based programs on households' relocation decisions.

Galiani et al. (2015) and Geyer (2017) use structural sorting models to simulate how the parameters of housing voucher programs affect households' neighborhood and housing consumption choices. Using U.S. data, both papers find that the details of the voucher program affect voucher recipients' choice regarding the trade-off between housing consumption and neighborhood quality. To our knowledge, similar evidence comparing the performance of different programs and program parameters in a European context is lacking.

One important reason for trying to understand the effect of housing programs on neighborhood quality and socio-economic mix is related to neighborhood effects. Although the mechanisms behind these effects are not well understood, there exists some credible evidence on the causal effects of neighborhoods especially on children's long-term outcomes (Chetty et al., 2016 and Chyn, 2016). However, the effects may be context specific as, for example, recent studies from England do not find effects running from deprived neighborhoods to student performance (Gibbons et al., 2013 and Weinhardt, 2014).[4]

[3] These findings may be partially explained by the incentives within the LIHTC program that lead to more LIHTC development in locations with low market rent (Lang, 2012). On the other hand, Ellen et al. (2016) analyze both siting and tenant selection in the LIHTC program and find little evidence that the LIHTC is increasing the concentration of poverty.

[4] For more discussion on neighborhood effects, see Cheshire et al. (2008).

The programs may also have indirect or unintended effects on top of the direct effects discussed above. Renting housing units below market rents may lead to misallocation of the units as tenants lose the subsidy if they move to a private sector unit. The welfare effects from misallocation have been estimated in the context of rent control in the U.S. (Early, 2000 and Glaeser and Luttmer, 2003) and in public housing in the Netherlands (Van Ommeren and Van der Vlist, 2016) and they appear to be substantial.

Kattenberg and Hassink (2017) report that in the Netherlands the lock-in effects are strong especially for tenants with relatively high incomes. This issue is important when assessing which type of households benefit from public housing. If households are able to prolong their stay in public housing when their income increases, fewer low-income households have the opportunity to enter the public housing sector.

Rent regulation may also affect labor market outcomes. For example, Svarer et al. (2005) find that in Denmark the probability of finding a local job increases with the rent control intensity, whereas the probability of finding a job outside the local labor market decreases with the rent control intensity of the housing unit. Lui and Suen (2011) show that public housing tenants in Hong Kong tend to live farther away from their workplace than private market tenants.[5]

Finally, a number U.S. papers study the crowding-out effects of supply side housing subsidies (Malpezzi and Vandell, 2002, Sinai and Waldfogel, 2005, Baum-Snow and Marion, 2009 and Eriksen and Rosenthal, 2010). The evidence from these papers suggests that construction of public housing or supply subsidies more generally leads to substantial crowding-out in locations with inelastic housing supply. This means that the policy is unlikely to increase the overall housing stock in these locations. According to a recent Finnish study by Oikarinen et al. (2015), the housing supply in the Helsinki housing market is particularly inelastic, and thus, public housing may lead to substantial crowding-out of private construction.

These results have important general equilibrium implications. If housing supply is inelastic, both demand and supply side programs may lead to higher overall rental rate in the private rental market. The mechanisms behind the rent effects in the case of

[5] Gibbons et al. (2017) find that high neighborhood turnover has a negative effect on teenagers' educational outcomes in England. This suggests that lock-in effects may have indirect benefits as well.

public housing are described in Fallis and Smith (1984), Early (2000) and Leung et al. (2012). However, empirical evidence concerning the magnitude of these effects is largely lacking due to the difficulty of estimating general equilibrium effects.[6] Similar mechanisms may operate also in the case of tenant-based programs (for further discussion see e.g. Eerola and Lyytikäinen, 2017). Gibbons and Manning (2006) study the UK housing benefit program and do not find evidence of strong general equilibrium effects. Exploiting geographic variation in the size of the U.S. housing voucher system, Eriksen and Ross (2015) conclude that increased supply of vouchers did not affect the overall rental rate.

3. Institutional setting

The major place-based program that we analyze dates from the mid 1940's and consists of various subsidy schemes for construction and renovation of rental housing. The program is implemented by the Housing Finance and Development Centre of Finland (ARA), an off-budget governmental agency operating under the supervision of the Ministry of Environment. The same program covers both public housing owned by municipalities and privately-owned subsidized housing owned by non-profit corporations and associations.[7] The details as well as the stated objectives of the policy have changed over time. Currently, the main objective is to provide affordable housing for low-income households. The program also aims at creating socially balanced neighborhoods and diversified buildings in terms of household composition. In addition, part of the stock is explicitly directed towards special groups (the disabled, students and the elderly).

Details of the public housing program in Helsinki. There are some 350,000 housing units in Helsinki almost half of which are rental units. Roughly 20% of the total

[6] Some papers have analyzed the effects of rent control on the rents of uncontrolled units in the same housing market. E.g. Early (2000) finds that rent control increases the rents of uncontrolled units. In addition, some papers have studied more localized spillover effects of public housing and rent control on nearby uncontrolled units (see e.g. Sims, 2007, Baum-Snow and Marion, 2009, Autor et al., 2014 and Diamond and McQuade, 2016).

[7] Technically, the public housing buildings are also owned by limited liability companies, which are owned by the municipalities.

housing stock is subsidized through the various schemes implemented by ARA.[8] Close to 70% of these subsidized units are public housing units owned by the city of Helsinki.

The public housing units are subject to different forms of regulation. The rents are cost-based and depend on the capital and maintenance costs of the building. In Helsinki, the buildings are situated at lots owned by the city, which the city rents at a discount. The lot rent discount directly lowers the capital cost of the building, which is then passed on to the tenants in the form of lower rents. Furthermore, the rules imply that the rent paid by the tenant does not depend on the characteristics of the tenant.

Tenant selection is based on legislation. The selection criteria include the applicant's urgency of housing need, its wealth and income. However, there is no explicit ranking of the applicants or a formal queuing system. The applicants cannot apply for a specific flat, but instead they have to specify one or several neighborhoods from which want to rent a flat. In addition, once a household has obtained a public housing unit, it has the right to occupy the unit indefinitely, even if its income increases.[9] The city aims at maintaining a diverse tenant structure in the buildings and in the larger neighborhood.

Details of the housing allowance program. The housing allowance program is financed by the government through the Social Insurance Institution of Finland (KELA). At the time of our study, the program consisted of a general housing allowance and separate schemes for pensioners and students. Subsequently, the student households have been moved into the general housing allowance scheme. In total, the housing allowance expenditures amounted to some 0.75% of the GDP in 2014.

The housing allowance is a means-tested benefit covering up to 80% of the rent up to a ceiling. The rent ceiling depends on local housing market conditions and is higher in more expensive regions. In addition, the allowance features a deductible if

[8] Scanlon et al. (2015) conclude in a study of 12 European countries that the share of public and privately-owned subsidized housing (jointly referred to as social housing) of the total housing stock varies from 2% in Spain to over 30% in the Netherlands. As the figures from Helsinki are close to the national averages, the subsidized rental housing sector in Finland is quite large in European comparison. As in many other European countries, this share has been slightly decreasing during the last ten years.

[9] The tenant selection rules with respect to household income have varied over the years. For example, in 2008 the explicit income limits were abolished in the initial selection phase, but reintroduced in the beginning of 2017 in the Helsinki Metropolitan Region. The income limits only apply at the initial selection phase meaning that a household is not obliged to relocate if its income increases above the initial limit. Our data come from 2011, when there were no explicit income limits in place.

household income exceeds an income limit which depends on the household size. Eligibility does not depend on tenure, but 95% of the housing allowance recipients live in rental housing. Also public housing tenants are eligible for the housing allowance.[10]

The system is similar to the housing benefit systems in other European countries, but differs from the U.S. housing voucher system in some important aspects. First, the Finnish housing allowances are an entitlement, while in the U.S. not all eligible households receive a voucher. Second, the Finnish program does not impose any requirements on the quality or the rents of the apartments of the recipient households. Typically, the landlord is unaware whether the tenant is housing allowance recipient or not.[11]

4. Data sources

We combine data from three sources:

Household register data. First, we use household level register data provided by Statistics Finland. The data consist of a 15% representative sample of all households living in Helsinki in 2011. The data include information on various household characteristics, income, taxes and social transfers including the amount of housing allowances. Furthermore, the data contain information about the household's housing unit. In addition to the units' physical attributes, such as floor area, number of rooms and age the data include the street address of the building. Moreover, the households' housing units can be classified according to tenure into owner-occupied, public rental housing, privately-owned subsidized rental housing, and private rental housing. An important limitation is that the data do not contain information on the rents paid by the households.

Building level data on public housing rents. The second data set comes from the city of Helsinki and includes *building level* information on the *average monthly rents per square meter* of the public housing units owned by the city (roughly 700 buildings in Helsinki). This rent information can be matched to the household level data using the address of the building. In some buildings, the rent per square meter is the same in all

[10] The formula used in calculating the housing allowance is the same for all rental households. For owner-occupiers a different formula is applied.

[11] See Eerola and Lyytikäinen (2017) for further details on the Finnish housing allowance system.

units. In others, it varies somewhat according to the size and the story of the unit. These within building differences are quite small meaning that rent per square meter together with information on the unit's floor area give us a quite precise measure of monthly rents of individual public housing units.

These rent data are not available for privately-owned subsidized rental housing. Therefore, we cannot to estimate the rent savings for the tenants in the privately-owned subsidized rental housing. This is the main reason for mostly focusing on public housing instead of the entire place-based program.

Housing unit level data on private rental market rents and unit attributes. Finally, in order to estimate rent savings for the public housing tenants, we need to predict the market rents for 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. We accessed the website on a weekly basis starting in May 2012 until the end of December 2013.

The website covers the whole of Finland, but we use information on units in Helsinki. The final estimation sample includes only the units owned by institutional landlords who typically own an entire building instead of individual units. In these cases the posted rent is equal to the actual rent paid. We exclude units owned by private persons advertising in the website because they are more likely to engage in bargaining with the potential tenant. We also exclude furnished units and units owned by non-profit organizations.

Each observation contains the rent of the unit, the street address and detailed information about the physical attributes of the unit. Thus, these data can be used to predict what the market rent of a particular public housing unit in a particular building would be based on the unit attributes that are available both in the household level data and the private rental market unit data.

5. Estimating the rent savings from public housing

5.1 Descriptive statistics

The first step in our analysis is to estimate the market rents 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 housing units in our private rental market sample and the public housing units in our household level data. There are 5,109 public housing tenants in our sample, but for 55 tenants we are not able to match rent information from our public housing rent data. The table shows, for example, that the average monthly rent per square meter in public housing (9.81) is roughly half of the average rent in the private rental market (19.3). However, the difference in the average rents is not 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, older and situated farther away from the central business district (CBD) than private market units.

Table 1. Descriptive statistics: housing units.

	Private rental market		Public housing	
	Mean	Std. Dev.	Mean	Std. Dev.
Observations	4,737		5,064	
Rent per m^2 (€)	19.3	4.27	9.81	0.77
Floor area (m^2)	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 come from Vuokraovi.com. The public housing rent data come from the city of Helsinki and the public housing unit characteristics data come from Statistics Finland.

The map in Figure 1 further illustrates the spatial distribution of the public housing units in our data. The map includes data only from those zip codes where we have data on both private and public housing units. The CBD is situated in the south-western peninsula. 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. When moving 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-family detached houses.[12] These observations motivate the use of hedonic regression techniques in recovering reliable estimates of the rent savings accruing to public housing tenants.

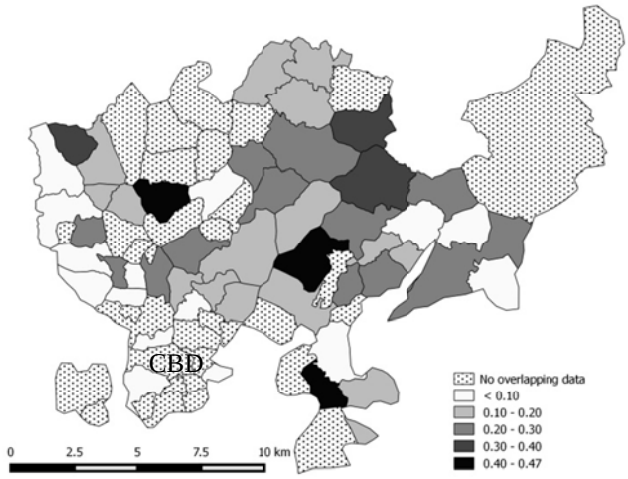

Figure 1. Share of public housing units by zip code.

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 is measured relative to all housing units including owner-occupied units. The CBD is situated in the south-western peninsula.

5.2 Hedonic regression

In a hedonic model, housing units are treated as differentiated products and a 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 public housing unit.

We estimate the following linear hedonic rent regression:

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

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

where p_{ij} is the monthly rent of a private market unit *i* in zip code area *j*, **x** are the unit's physical attributes including distance to CBD, μ_j represent zip code area fixed effects that capture unobservable location specific attributes, and *u* is the error term.[13] Helsinki is divided into some 80 zip code areas 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 rental market data only from these areas (see Figure 1).

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 estimating the hedonic model, 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 and quality of the unit. There may be differences in the condition and quality of the units in the two sectors as

[13] We use a linear form for the hedonic regression because it is easier to interpret and relies on less restrictive statistical assumptions for prediction purposes compared to a log-linear form. See e.g. Manning and Mullahy (2001) and Wooldridge (2006).

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 these omitted variables.

Unfortunately, there is little we can do to address this problem with the data at hand, but we should note that our predictions will most probably produce an upper bound for the market rents of the public housing units. At the same time, we believe that the relative rent savings within the public housing sector are more reliable. For example, if quality and condition differences are not related to the location of the unit, any spatial differences in the rent savings reflect true heterogeneity in the subsidy that public housing tenants receive.

In order to assess the accuracy of our prediction, we draw a 10% random sample from the private rental market data which we do not use in the estimation. We then predict the market rent and calculate a prediction error for each private rental unit in the sample. On average, this out-of-sample prediction error should be zero and it should not vary systematically with observable unit attributes. The degree of variation in the out-of-sample prediction is also useful in interpreting the subsidy estimates.

5.3 Determinants of the public housing 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 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.

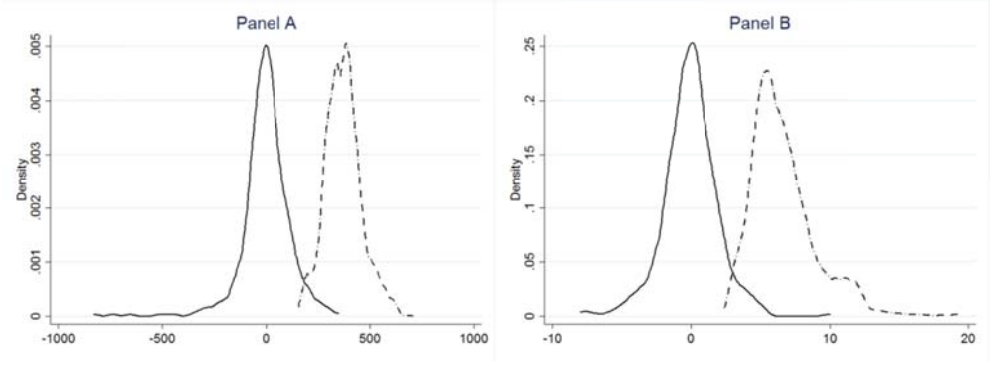

Figure 2. Distributions of public housing subsidy and prediction error for private units.

Notes: Panel A depicts the monthly subsidy (€) and Panel B the monthly subsidy per square meter (€/m^2). The solid line refers to private rental units and the dashed line to public housing units.

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). None of the physical attributes of the hedonic regression can explain the prediction error in the out-of-sample units and only one out of the 44 zip code fixed effects is statistically significant at 5% level. 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 with respect to unit characteristics. 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 private 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.

The coefficients reported in column (3) do not contain information about households' marginal willingness to pay for unit attributes. They simply reflect the pricing schedule of the city. The rents in public housing units are set administratively. In some cases, the rent per square meter is the same in all units of the building. In other cases, it also depends on the floor area and the story of the unit. This pricing rule explains the very high R^2 for public housing units.

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 main central railway station). As the figure shows, the monthly subsidy to a given housing unit decreases with the distance to the CBD (Panel A). The same pattern arises if we measure the monthly subsidy per square meter (Panel B). [14]

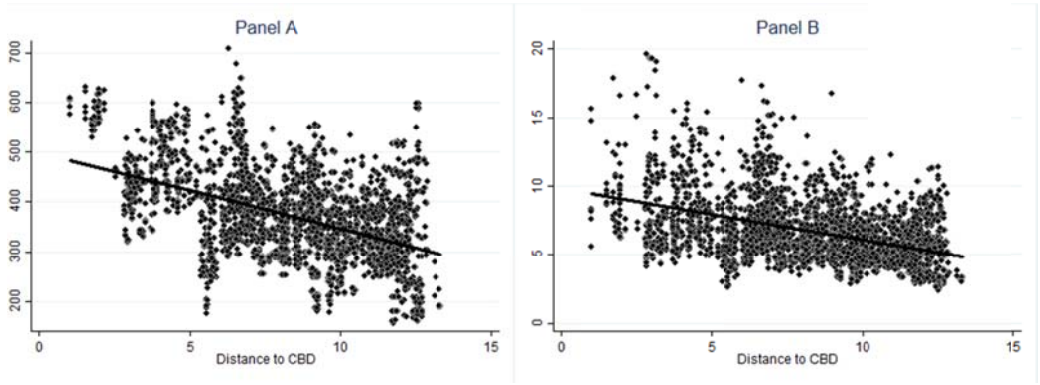

Figure 3. Public housing subsidy according to distance to CBD.

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 code areas. 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.

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

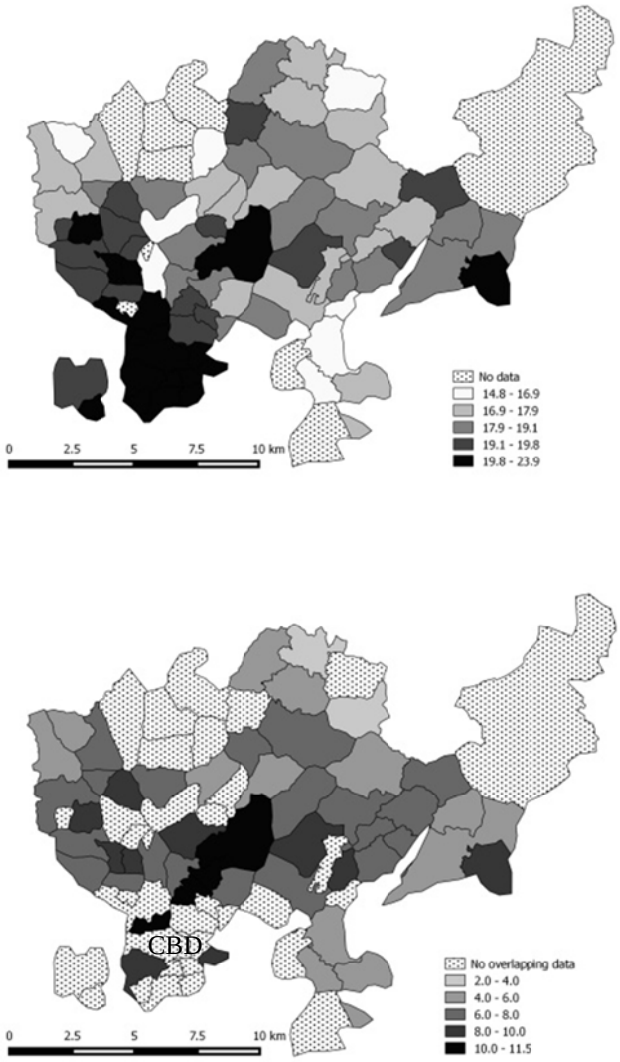

Figure 4. Market rents (top) and public housing subsidy (bottom) by zip code area (€/m^2/month).

Notes: The CBD is situated in the south-western peninsula.

It should be kept in mind that the spatial variation in the size of the subsidy observed in Figure 3 and 4 does not necessarily mean that the system is poorly designed. Instead, variation may be necessary in order to influence the neighborhood social mix by facilitating low-income households' access to expensive neighborhoods. Next, we turn to the issue of what type of households benefit from the programs and how the programs succeed in promoting mixed-income neighborhoods.

6. Household analysis

6.1 Distributional effects

In this section, we link our estimates of the unit specific subsidies to the characteristics of the tenants and study the distributional effects of the subsidy. Table 3 first shows some descriptive statistics of owner-occupiers, private rental housing tenants and public housing tenants in our data.[15]

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 on average lower incomes, having more often small children and living in larger units.

Table 3. Descriptive statistics: households.

	Homeowners		Private rental		Public housing	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Observations	21,934		10,915		5,109	
Age of household head (years)	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 (0/1)	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 (0/1)	0.10	0.30	0.07	0.25	0.13	0.34
Housing allowance recipient (0/1)	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 and the mean public housing subsidy are calculated over households that received these subsidies. Disposable income includes the housing allowance, but does not include the public housing subsidy.

[15] For the most part, we leave out tenants in privately-owned subsidized units as we do not information about their rents and cannot therefore calculate their rent savings.

In order to study the distributional effects, we divide the households into income deciles based on their disposable income.[16] Panel A of Figure 5 presents the shares of different tenure (owner-occupied, private rental housing, public housing and privately-owned subsidized housing) in the income deciles. Two interesting observations stand out. First, in the lowest deciles, private rental housing is more common than 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% live 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.[17] For each decile, the figure shows the shares of the total public housing subsidy and the 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 two lowest 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.

[16] 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.

[17] The housing allowance includes both the general housing allowance and the pensioners' housing allowance. We exclude the students' housing allowance and the public housing subsidy received by students.

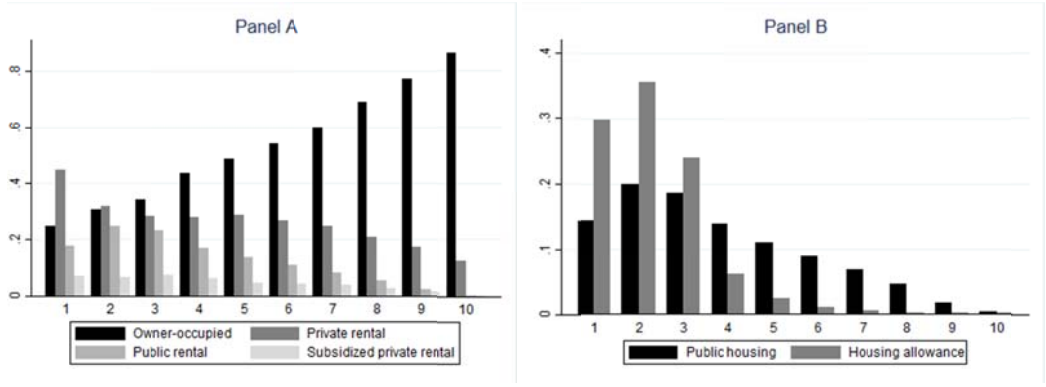

Figure 5. Housing tenure and distribution of subsidy by income decile.

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. 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).

Private rental tenant households 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.

The two housing programs also overlap. Roughly 40 percent of all housing allowance recipients live in public housing and almost half of the public housing tenants in the lowest income quintile also receive housing allowances.[18] 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.

[18] The total subsidy received by the public housing tenants cannot be calculated by simply adding up the two subsidies. If a public housing tenant paid the market rent, it would also receive a larger housing allowance.

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	1,768	1,673	1,005	559	104
Disposable income (€/year)	11,708	17,365	23,364	30,146	43,571
Household size	2.01	1.88	1.91	1.95	1.96
Mean floor area (m^2)	57.4	60.3	60.8	62.2	65.9
Housing allowance recipient (0/1)	0.48	0.18	0.04		
Housing allowance (€/year)	2,768	2,100	1,976		
Public housing subsidy (€/year)	3,461	3,499	3,463	3,368	3,418
Public housing subsidy (€/m^2/month)	6.99	6.50	6.58	6.52	6.47
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 recipient (0/1)	0.32	0.12	0.04		
Housing allowance (€/year)	2,562	2,123	1,615		

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 and the mean public housing subsidy are calculated over households that received these subsidies. Disposable income includes the housing allowance, but does not include the public housing subsidy. The average housing allowance is not reported in the two top quintiles due to the small number of recipient households in the sample.

6.2 Comparing neighborhood exposure

By reducing the price of housing relative to other consumption, both tenant-based and place-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 move to a larger unit or to a better neighborhood. Therefore, both tenant-based and place-based programs may influence the neighborhood quality that low-income households are exposed to. The evidence from the U.S. programs seems to suggest that place-based programs fare worse than tenant-based alternatives in this respect. However, it is not

clear that the same true in settings where the neighborhood mix is an explicit aim of the place-based program.

One reason for this is that place-based programs can be used to influence not only the location choices of low-income households but also who lives next to them. Targeting part of the public housing subsidy towards middle-income and high-income households can, therefore, be motivated by the aim of creating mixed-income neighborhoods and buildings. Furthermore, 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.

Within the Finnish program, the creation of mixed-income neighborhoods and buildings can happen through building location, tenant selection to a particular building and through the unlimited right to occupy the public housing unit. In this section, we compare the neighborhoods occupied by low-income public housing tenants and similar low-income households living in private rental units.

We use zip code areas and buildings to define a neighborhood and consider four neighborhood socio-economic mix and quality measures: the median annual 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 (Euros per square meter) 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 are reflected in market rents. The income, poverty rate and education measures are estimated from our household data. The average rental rate by zip code in the private rental market comes from Statistics Finland.

Our strategy is to compare the exposure of public housing tenants and private rental housing 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. Since we want to compare public housing tenants and private rental housing tenants that are similar in terms of life-cycle and family size, we control for the age of household head, whether the household has small children, whether the household is single and the number of person in the household. We also exclude all student households from these analyses. It should be stressed that our aim is not to estimate the causal effect of public housing tenancy on households' neighborhood quality, but instead to describe and compare the neighborhoods that households are exposed to.

Table 5 reports the estimation results for the zip code area level using a sample of only private rental housing tenants and public housing tenants.[19] 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 in the private rental sector.

The more interesting result for our purposes concerns the sorting of public housing tenants compared to private rental housing tenants. Two results stand out from Table 5 in this respect. First, the public housing tenants in the lowest income quintile live in poorer, less educated and lower quality neighborhoods than similar private rental housing tenants in the same income 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 neighborhoods where their neighbors are more similar to them 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.[20]

[19] 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.

[20] It is possible that private rental housing 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

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 code areas 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 fifth income quintile indicates that the public housing tenants live in zip code areas with lower median income (by 1,451 Euros) and lower share of households with a master's degree (by 3.6 percentage points). This may be partially explained by the fact that in the fifth income quintile the private rental tenants have on average higher incomes than the public housing tenants (see Table 4).

differences is to focus on those low-income households that are housing allowance recipients during 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. quintile	54.18	-0.004**	0.002	0.051
	(122.7)	(0.002)	(0.004)	(0.142)
3. quintile	683.9***	-0.011***	0.016***	0.326*
	(171.8)	(0.002)	(0.004)	(0.170)
4. quintile	1315***	-0.016***	0.034***	0.761***
	(263.0)	(0.004)	(0.006)	(0.249)
5. quintile	2622***	-0.029***	0.066***	1.370***
	(400.6)	(0.005)	(0.010)	(0.342)
1. quintile * public tenant	-2392***	0.014*	-0.076***	-2.407***
	(476.6)	(0.008)	(0.013)	(0.509)
2. quintile * public tenant	94.71	-0.000	0.003	0.029
	(145.0)	(0.003)	(0.004)	(0.168)
3. quintile * public tenant	-253.6	0.002	-0.004	-0.259
	(212.7)	(0.003)	(0.006)	(0.199)
4. quintile * public tenant	-742.81*	0.007	-0.019**	-0.456
	(319.5)	(0.005)	(0.008)	(0.306)
5. quintile * 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.

This rather strong sorting by income also within the public housing sector is somewhat surprising. There are at least three potential explanations for this finding. First, the rental rate in public housing units tends to be higher close to the CBD. Although the between neighborhoods rent differences in public housing are much less pronounced than in the private rental market, it could be that higher rents induce low-income households to seek public housing units from less expensive neighborhoods. Second, since the rent savings tend to be larger in more sought-after neighborhoods

with higher market rents, the lock-in effects may also be larger in these neighborhoods. This means that public housing tenants in attractive neighborhoods may be less likely to move when their income increases because by moving they have to give up substantial rent savings. In less sought-after neighborhoods where rent savings in public housing are smaller, public housing tenants may be more willing to move from public housing when their income increases. Finally and in connection to the second point, the public housing units in sought-after neighborhoods may become vacant less frequently (see also Kattenberg and Hassink, 2017). Low-income households may not be able to afford to wait for such a unit, and therefore, are not selected into attractive locations.[21]

Next we turn to building level outcomes. In Table 6 we report the results of the neighborhood exposure estimation at the building level.[22] 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.[23] 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 in the private rental housing.

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, private rental housing tenants often live in the same buildings with owner-occupiers. Because owner-occupied households have on average higher incomes these mixed-tenure buildings tend to be more mixed-income than those that are reserved for public housing tenants only.

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

[22] 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.

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

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. quintile	799.1***	-0.078***	0.001
	(263.5)	(0.011)	(0.008)
3. quintile	2434***	-0.109***	0.006
	(305.1)	(0.011)	(0.009)
4. quintile	4899***	-0.136***	0.059***
	(599.4)	(0.018)	(0.011)
5. quintile	5913***	-0.149***	0.093***
	(747.6)	(0.020)	(0.014)
1. quintile * public tenant	-4139***	0.083***	-0.122***
	(482.0)	(0.022)	(0.010)
2. quintile * public tenant	515.5	-0.027	0.004
	(390.4)	(0.020)	(0.009)
3. quintile * public tenant	-514.2	-0.005	-0.001
	(512.1)	(0.024)	(0.010)
4. quintile * public tenant	-2863***	0.033	-0.060***
	(853.4)	(0.034)	(0.013)
5. quintile * 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. These similarities suggest that it is difficult to design place-based housing programs so that poor tenants would not end up in poorer quality neighborhoods compared to households that receive tenant-based subsidies and have the freedom to choose their neighborhood. This is true even in Helsinki where social mixing has been a stated goal of the program throughout its history.

7 Conclusions

This paper analyzes the relative merits of large place-based and tenant-based programs in Finland by comparing their effects on housing affordability and on neighborhood quality. We estimate that the total rent savings to households living in public housing units in Helsinki is considerable and comparable in size to the housing allowance, the main tenant-based housing program. This public housing subsidy depends on the physical attributes of the unit and especially its location. It decreases substantially as the distance to the CBD increases. When comparing the distribution of the public housing subsidy to that of the means-tested housing allowance, we find that the public housing subsidy is clearly less targeted towards low-income households.

In the second part of the paper, ask whether directing a share of the public housing subsidy toward middle- and high-income households work as intended in preventing the spatial concentration of poor households. Our results indicate that the low-income public housing tenants live in poorer, less educated and lower quality neighborhoods (measured either at the zip code or at the building level) than similar private rental housing tenants in the same income quintile. This finding suggests that public housing programs may lead to more segregation than tenant-based alternatives even when neighborhood mixing is an explicit aim of the program.

Several important questions remain unanswered. Perhaps the most important ones are related to the effects of major reforms. Because the public housing sector constitutes a large share of all rental housing in Helsinki, it may influence the rental rate in the private rental market. A large reform would result in a new sorting equilibrium with new equilibrium housing prices. Therefore, such policy changes cannot be evaluated without taking into account general equilibrium effects. Tackling this issues using structural sorting models in the same way as Galiani et al. (2015) and Geyer (2017) in the case of the U.S. housing voucher program seems like a fruitful avenue for future research.

Acknowledgments

This paper was previously circulated under the title “Who benefits from public housing?”. We thank Heikki A. Loikkanen, Teemu Lyytikäinen, Niku Määttänen, Mattias Nordin, Marko Terviö, Otto Toivanen and the seminar participants in the

FEAAM, IIPF, UEA and OFS for useful comments. Jaakko Meriläinen and Ville Mäkinen provided excellent research assistance. We also wish to thank the city of Helsinki for providing data and the Academy of Finland for funding (Project "Modeling Housing Market Frictions – Tools for Policy Analysis", grant number 255445).

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