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City-wide effects of new housing supply: Evidence from moving chains

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Abstract

We study the city-wide effects of new, centrally-located market-rate housing supply using geo-coded total population register data from the Helsinki Metropolitan Area. The supply of new market rate units triggers moving chains that quickly reach middle- and low-income neighborhoods and individuals. Thus, new market-rate construction loosens the housing market in middle- and low-income areas even in the short run. Market-rate supply is likely to improve affordability outside the sub-markets where new construction occurs and to benefit low-income people.

JEL: R31, R21, R23

Keywords: Housing supply, Housing affordability, Filtering.

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1 Introduction

Housing affordability is a major issue in most cities throughout the world. A large body of economic research argues that this is due to shortages in housing supply driven by local regulatory restrictions (e.g. Glaeser and Gyourko 2018). Economists tend to offer a simple solution to this problem: allow for more housing construction in areas of high-demand and housing prices and rents will go down and more people will be able to move in. However, opposition to new buildings, especially when built in existing neighborhoods, is strong for a number of reasons. Homeowners want to protect the value of their most important asset. Current residents do not want the character of their neighborhood to change or the neighborhood to become overcrowded. Some even question the economists' central claim that new market-rate housing improves housing affordability for most people, as new market-rate housing tends be expensive, thus only benefiting the better-off. These groups can form a powerful political force at the local level and stiffen local housing supply (see e.g. Glaeser and Ward 2009, Hilber and Robert-Nicoud 2013, Ortalo-Magné and Prat 2014, Einstein et al. 2019 and Been et al. 2019). Because of this opposition, information on the total benefits of new market-rate housing is crucial for local politicians who ultimately make decisions on how much and where to allow new construction to take place.

In addition to the direct effect of increasing the housing stock in the neighborhood it is built in, new market-rate housing may have more far-reaching indirect effects through a moving chain process. As new residents move into the newly constructed units, they vacate their old units. These vacant units then get occupied by a new set of residents whose old units become vacant and so on. Through this process, new market-rate housing can have moderating price effects in the city's lower-income neighborhoods, not just in its immediate neighborhood, by effectively loosening the housing market in these areas through vacancies.[1] However, if a city's housing market is segmented into separate sub-markets so that people do not move between them, the moving chains may not reach low-income neighborhoods. Whether and to what extent this is the case is ultimately an empirical question.

In this paper, we use Finnish total population register data to shed further light on how new, centrally located buildings affect surrounding sub-markets through a moving chain mechanism. Our data are particularly well-suited for this analysis as they include information on the exact location and housing unit for all households.[2] Thus, we can

[1] In the longer run, filtering can also take place through depreciation where houses become more affordable as they age (see e.g. Rosenthal 2014; Rosenthal 2020; Weicher and Thibodeau 1988 and Liu et al. 2020).

[2] For buildings with at least three households, we observe exact coordinates. For buildings with fewer households, we observe coordinates at a level of 250 square meter grids.

follow the moving chain at housing unit level and identify the neighborhoods in which the units in the chain are located. Moreover, we observe the individuals living in these units, and thus, we can characterize the movers as well using our rich register data. We focus on new buildings in the Helsinki Metropolitan Area (HMA), home to about 1.2 million individuals (20% of Finland's population).

We start by showing that people moving into the new centrally located buildings (we refer to this as round one in the moving chain) have much higher incomes and are more likely to be highly-educated than both the HMA population on average and the people who move to other locations in the HMA during our time window. New housing built in expensive areas of the city does indeed primarily house the better-off. However, the moving chains triggered by these new units reach middle- and low-income neighborhoods quickly, within a year or two. Our register data also allows us to show that low-income individuals are part of the moving chains. This is direct revealed-preference evidence that low-income individuals in the city area also benefit from new expensive housing, even when the new units are allocated to individuals higher up in the income distribution.

In the time window we study, as part of a social mixing policy, a number of new rent-controlled social housing units were also built close to the city center. We can therefore compare how the moving chains triggered by new market-rate construction differ from those triggered by new social housing construction. Unsurprisingly, in the case of social housing a high share of moves originate from lower-income neighborhoods already in the first round, and the share does not change substantially, if at all, by round six which is the final round of our analysis. Interestingly, by round four of the moving chains the neighborhood and individual incomes are very similar for chains triggered by market-rate and social housing. At the same time, we do see that first-round movers to new centrally located social housing units are positively selected in terms of income and education relative to movers to other social housing units in the HMA, suggesting that these units may not be going to the individuals who need them the most. This result can be explained by the fact that rents in social housing tend to be higher in more centrally located areas compared to areas farther away (see Eerola and Saarimaa 2018).

Finally, we reconstruct the sequence of origin units in the moving chain and calculate the overall probability that the chain reaches lower-income sub-markets. We find that for each 100 new, centrally located market-rate units, roughly 29 (60) units are created in the bottom-quintile (bottom half) of neighborhood income distribution through vacancies. Given that the moves we study happen between two adjacent years, i.e. we study the very short-run, these numbers are significant. The corresponding figures for social housing units are 43 and 75, respectively.

This paper complements the recent work by Mast (2021), who shows that in major

US cities moving chains triggered by new housing in central and expensive parts of cities do reach middle- and low-income neighborhoods quite quickly. We provide empirical evidence on how the moving chain mechanism unfolds in a European city where income inequality and segregation are more moderate compared to US cities. Our results echo those reported by Mast (2021), but with some notable differences. Compared to US cities, the moving chains in the HMA are more likely to reach middle- and low-income neighborhoods and reach them faster. The difference may be partly driven by differences in the data and methodology used to construct moving chains, but they probably largely reflect differences in underlying income inequality and residential segregation. That is, the socio-economic distance between expensive and affordable neighborhoods is smaller in the HMA compared to US cities. Furthermore, Mast (2021) uses address history data, but has only limited background information on the individuals. Our register data allows us to go beyond characterizing neighborhoods and provide direct evidence that lower-income individuals are part of the moving chains.[3]

Our results also inform the recent literature comparing the effects of different housing policy options, such as upzoning, housing vouchers and rent control, using calibrated general equilibrium models (see e.g. Favilukis et al. 2019 and Nathanson 2020). Empirical estimates on the extent of segmentation of the housing market within cities is a key component in understanding the relative merits and distributional consequences of these policy options (Piazzesi et al. 2020).

It is important to note that our results speak to the potential of new construction to loosen middle- and lower-income sub-markets in the metropolitan area. However, we cannot make any claims about the effect of new construction on the immediately surrounding neighborhoods (see e.g. Diamond and McQuade 2019; Li 2019; Singh et al. 2019; Pennington 2020; Asquith et al. 2021), nor do we look at price effects in the neighborhoods reached by the moving chains (see e.g. Mense 2020).

The rest of the paper is organized as follows. In the next section, we present our data and research design. Section 3 presents the main results and section 4 concludes.

[3]Turner (2008) and Turner and Wessel (2019) estimate vacancy chain models using administrative data from Stockholm and Oslo, respectively, but they do not focus on the socio-economic makeup of the neighborhoods. Moreover, the neighborhood divisions in these papers are very coarse (two areas in Stockholm and four in Oslo).

2 Institutional setting and data

2.1 HMA housing market

The HMA consists of four municipalities (Helsinki, Espoo, Vantaa and Kauniainen) that together comprise a unified commuting zone. The total population of the area is roughly 1.2 million individuals and there are some 585,000 housing units, 45% of which are rental units. Roughly 18% of the total housing stock is rent-controlled social housing. In the rest of the stock, prices and rents are determined in markets.

Social housing refers to rental housing provided either by non-profit entities or by the municipalities. The main goal of the social housing program is to provide affordable housing for low-income households, but the program also aims at socially mixed neighborhoods and buildings. This is why these units are located also in expensive areas and why the tenant selection rules are not overly restrictive with respect to tenants' incomes (see Eerola and Saarimaa 2018). The rents in social housing buildings are regulated and typically much lower than market rents, especially near the Helsinki city center.[4] In addition, part of the social housing stock is explicitly directed towards special groups, such as the disabled, students and the elderly.

2.2 Finnish register data

We use geo-coded register data containing information on all residents in Finland over the 2009-2019 time period. The data includes rich demographic and socio-economic characteristics, such as age, gender, income, education and number of children. We can link individuals to both the buildings and the housing units they reside in at the end of each calendar year. For each building, we have granular location information: provided that there are at least three households living in the building, we know the exact coordinates of the building. Otherwise, the coordinates refer to 250 square meter grids.

2.3 New buildings

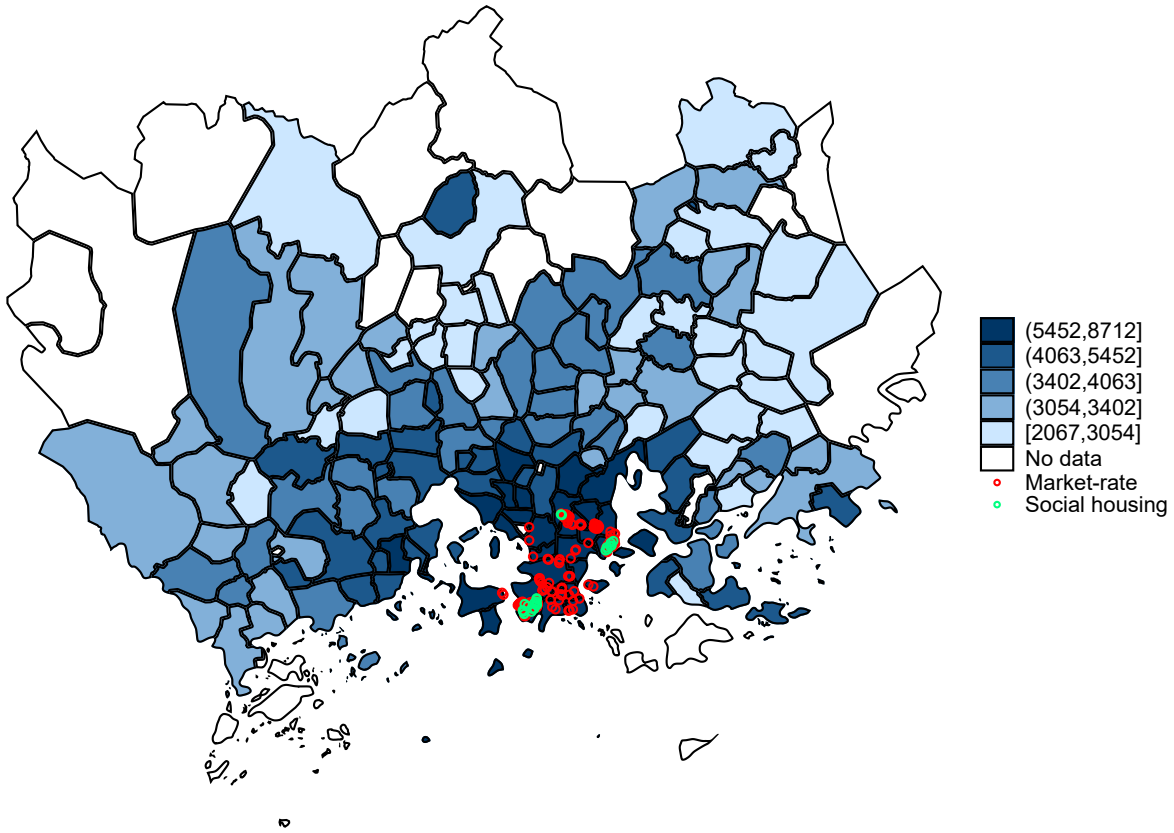
We study new multi-unit buildings built between 2010 and 2019 within a three-kilometer radius of the Helsinki Central Station, the focal point of the central business district.

[4]More precisely, social housing rents are cost-based and depend on the capital and maintenance costs of the building including land rent. Most of the social housing buildings are situated on lots owned by the city of Helsinki and lot rents collected by the city are well under market rents for land. This discount in land rent is then transferred to tenants in the form of lower housing costs. While the rents in social housing units are lower than market rents, they are spatially correlated with market rents, mostly due to the land component in the cost structure. According to estimates in Eerola and Saarimaa (2018), the difference between market and social housing rents is largest in centrally-located neighborhoods.

We identify new buildings in the data by the first year they appear in the register and classify them as market-rate or social housing.[5] We exclude student housing and other types of special housing (e.g. housing for the elderly, assisted living etc.) from the set of new buildings that we consider, but allow moving chains to pass through these types of buildings.

Figure 1 illustrates the location of these buildings and mean housing prices per square meter in Helsinki Metropolitan Area (HMA) zip codes. As can be seen from the figure, the new buildings in our sample are located in the most expensive areas of the HMA, regardless of whether they are market-rate or social housing buildings.

Figure 1: New buildings and zipcode mean housing prices (€/m^2).



Notes: The red and green dots denote new buildings built in 2010-2019 that lie within a three-kilometer radius from the Helsinki Central Station. Housing prices are from 2019 and obtained from Statistics Finland.

[5]Figure A1 shows the number of buildings we have in our sample by year and building type.

3 Constructing moving chains

In constructing moving chains, we allow individuals to move to the new buildings from any location.[6] This implies that they can move from outside the HMA as well and we do not impose restrictions on the type of building they lived in prior to moving.

We construct the moving chain in the following way. We identify the individuals that move into the new buildings during the first year the building enters the register. We call the year when this move happens year t. We then follow these individuals back in time and find the units where they used to live the year before the move. We call this year $t-1$ and the units they leave origin units.[7] We classify origin units based on the characteristics of the neighborhoods they are located in and based on whether they are located in the HMA or not. In the next step, we identify the individuals that in year t live in the origin units as defined above. We then follow this second set of individuals back in time and find *their* origin units and classify them in terms of neighborhood characteristics and HMA status. We continue in this manner for a total of six rounds, which corresponds to the analysis by Mast (2021) using US data.

The underlying aim of this exercise is to take note of the type of neighborhoods the moves originate from and what type of people move in each round. We classify HMA neighborhoods into ten equal-sized groups or neighborhood income deciles based on the neighborhood residents' median disposable income.[8] That is, the number of neighborhoods is the same in each decile. We first aggregate individual disposable income at the household level and then scale the income using the OECD equivalence scale. The scaling assigns value 1 to the first adult household member, 0.7 to each additional adult and 0.5 to each child.

Our baseline neighborhood definition is a zip code area. There are 165 zip codes in the HMA (in 2019) with a mean population of roughly 6,800. Some zip codes are geographically quite large and include different types of smaller neighborhoods with distinct residential makeups. A problematic example for our analysis would be a predominantly low-income zip code that contains an affluent single-family house residential area. This would bias our results in the sense that while our moving chains might reach this low-income zip code, it could be the better-off residents within the zip code area that are actually moving. In this case, the moving chain would not effectively loosen the housing

[6] We omit two origin zip codes which primarily house students (one of the campuses of the University of Helsinki is situated in Viikki and the main campus of Aalto University is situated in Otaniemi). These would be classified as low-income neighborhoods with the income measure we use, but these zip codes do not really house economically deprived individuals.

[7] This means that we always look at moves that happen between two adjacent years.

[8] The precise income concept is disposable money income, which is defined by Statistics Finland and includes wages and salaries, entrepreneurial income, property income and current transfers received subtracted by current transfers (mostly direct taxes) paid.

market that is relevant for lower income people. Thus, as our second neighborhood definition we use 250 square meter grids, which are smaller units than zip codes and less likely to produce the above-mentioned problems. In 2019, there were in total 6,228 populated grids in the HMA with an average population of slightly less than 200.

Of course, even with a fine-grained neighborhood division, there can still be systematic differences in unit quality so that the moving chains take place within predominantly high-quality units within each neighborhood (see also Mast 2021). Again, this would mean that even though a moving chain reaches a low-income neighborhood, it would be the better-off residents that move out. To tackle this issue further, we take advantage of our rich register data that allow us to directly analyze what type of individuals in terms of income participate in the moving chains. This provides direct evidence on whether new centrally located buildings affect the lives of low-income people in the city.

A chain can break for a number of reasons before reaching round six. First, a chain breaks if a vacated unit gets occupied by someone moving from outside the HMA.[9] Second, in some instances the origin unit is in the HMA, but does not become vacant. Examples of this includes a young person moving away from her parents house or a divorce where one or more members of the household remain in the origin unit.

4 Results

4.1 Mobility across neighborhoods

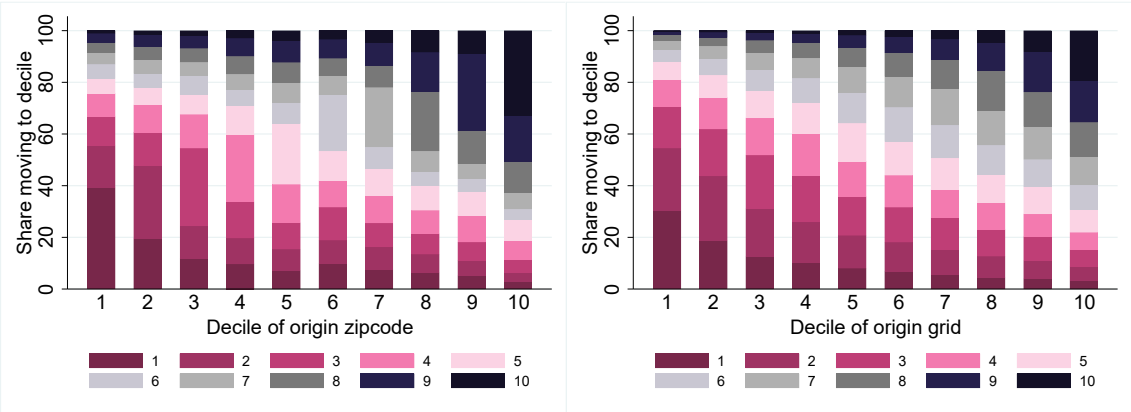
We first document patterns of mobility between different types of neighborhoods, defined as zip codes and 250 square meter grids, within the HMA. This gives us the first indication of how segmented the HMA housing market is. We consider moves that happen in destination years 2010 to 2019. We characterize both origin and destination neighborhoods in terms of where they are in the distribution of median disposable income as explained earlier, relative to all neighborhoods in the HMA (i.e. not in the national-level distribution).

Figure 2 shows that there is a fair amount of mobility across different types of neighborhoods in the HMA. While a majority of moves originating in the first income decile are to neighborhoods below the median in the neighborhood income distribution, we see that around 15-20% of moves are to neighborhoods classified above the median, depending on the neighborhood definition. Similarly, roughly 35% of moves originating in the tenth decile are to neighborhoods below the median. These numbers suggest that even the

[9]We should note, however, that in some rare cases a chain may come back to the HMA even when it leaves at some earlier round. We include this type of chains in our main analysis.

extreme ends of the neighborhood distribution can, in principle, be connected through moving chains in just a few rounds.

Figure 2: Mobility across neighborhoods



(a) Zip codes (b) 250m grids

Notes: These transition matrices show the likelihood of moving across different kinds of neighborhoods in the Helsinki Metropolitan Area, given origin neighborhood disposable income decile.

4.2 Who are the first round movers and where do they move from?

Next, we provide summary statistics on the people who move into new centrally located buildings. We also compare these movers to those HMA residents who do not move within the time window of our analysis and to those who move to other areas in the HMA. We further break this analysis down by whether the new building is market-rate or social housing.

Panel A of Table 1 shows these statistics for market-rate destination units. We see that movers to new, centrally located buildings have indeed on average higher incomes and are more educated than stayers or movers to other destinations. This is unsurprising given the fact that these are central and expensive locations.

Panel B of Table 1 shows that the movers to centrally located social housing buildings are also positively selected: they have higher incomes and are more educated than both those staying in social housing and those who move to other social housing buildings within the HMA. This could be due to the fact that, even though the rents are regulated in these units, the regulated rents tend to be slightly higher in more expensive neighborhoods (Eerola and Saarimaa 2018). Comparing movers to new social housing units to movers to new market-rate buildings, we see that the income of the former group is roughly two-thirds the income of the latter group.

Table 1: Summary statistics for movers and stayers

	Stayers	All movers	Movers to new buildings
Panel A: Market-rate units			
Age household head	56.25	36.91	40.67
	[14.91]	[13.22]	[13.91]
Median household disposable income	27,617	24,216	33,841
	[60,730]	[55,910]	[50,782]
In MA or above household	0.329	0.279	0.460
Household with children	0.429	0.396	0.310
Number of observations	3,730,715	1,134,761	5,170
Panel B: Social housing units			
Age household head	51.43	33.94	38.23
	[15.86]	[13.60]	[11.98]
Median household disposable income	17,354	16,267	20,505
	[10,019]	[9,492]	[7,263]
In MA or above household	0.078	0.082	0.201
Household with children	0.431	0.410	0.585
Number of observations	751,002	418,318	2,336

Notes: Stayers are defined as those that did not move over the 2009-2019 time period from their market-rate units (Panel A) or social housing units (Panel B). All movers exclude movers to new, centrally-located market-rate units (Panel A) or social housing units (Panel B). Standard deviations are reported in brackets.

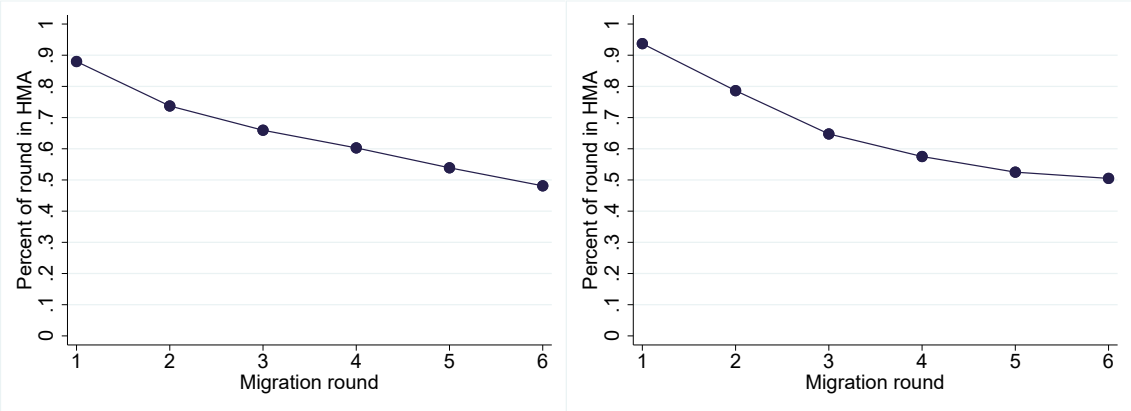
In Figure A2 in the Online Appendix, we show the spatial distribution of first round movers' origin neighborhoods at the zip code level. We highlight two things for market-rate units. First, people tend to move short distances, and second, consistent with them having higher incomes, the first round movers come from relatively expensive neighborhoods. For social housing, the results are surprisingly similar: movers to new social housing buildings also move from close-by neighborhoods.

Overall, the movers to new, centrally located market-rate buildings are a positively selected group relative to both those who do not move and movers to other destinations in the HMA. Next, we turn to the question whether this means that these new buildings only benefit these well-off individuals.

4.3 Moving chains

Before characterizing the origin neighborhoods and movers in each round, we show the share of individuals originating from the HMA in each round. In Figure 3, we see that, while in round one, around 90% of movers are from the HMA, this share gradually decreases to 50% by round six, regardless of the type of new building we look at. The gradual decline in the share of moves originating within the HMA reflects one main reason why moving chains break before they reach low-income neighborhoods in the HMA.

Figure 3: Share of movers originating from the HMA at each round.



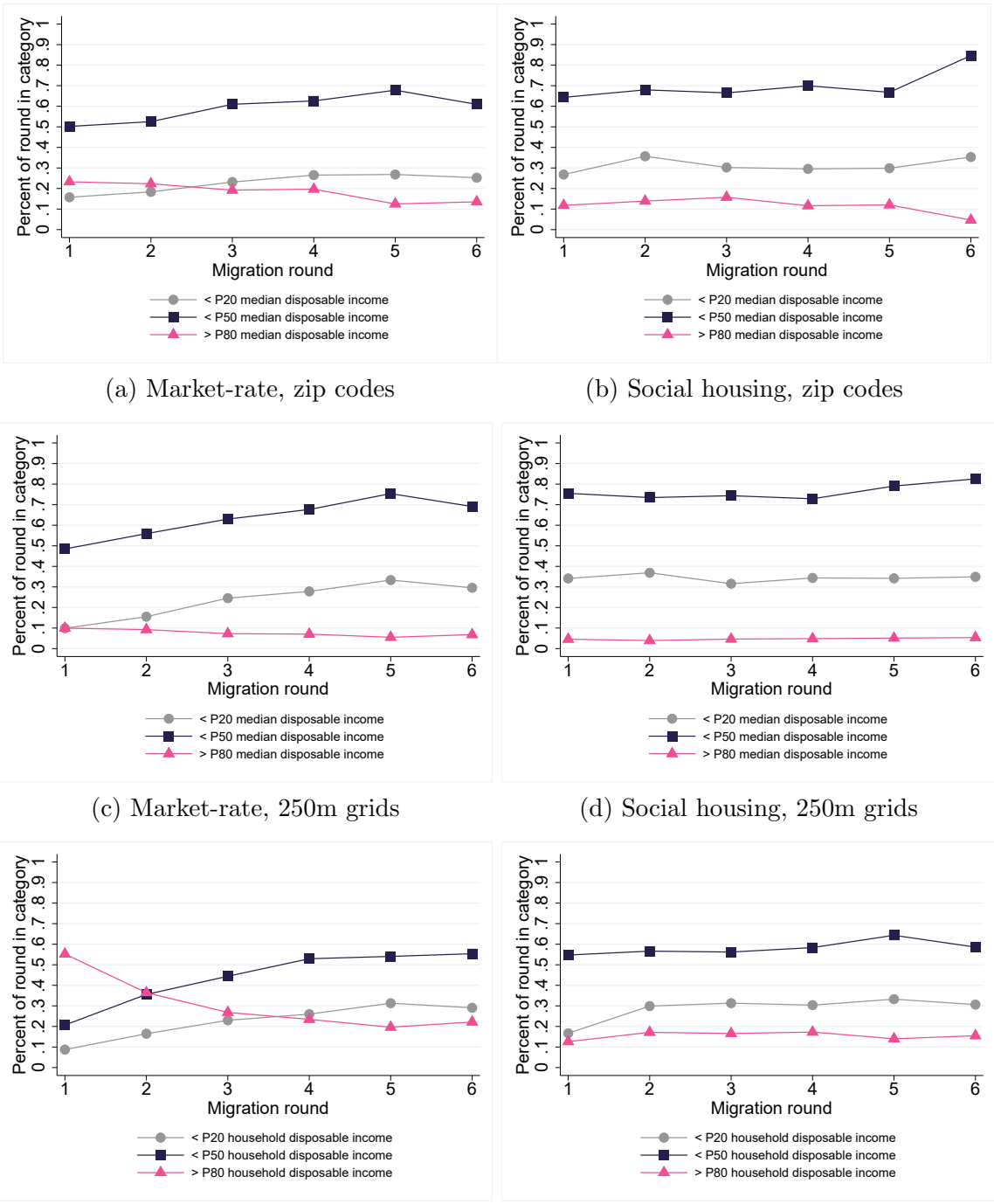
(a) Market-rate units (b) Social housing units

Notes: The left panel shows the share of movers originating from the HMA at each round when the first round destination building is market-rate. The right panel shows the corresponding shares when the first round destination building is social housing.

We present the main results of the paper in Figure 4, where we characterize the origin neighborhoods within the HMA and the income decile of the movers in each round. The figure depicts the shares of moves that originate from different parts of the neighborhood and household income distribution, separately for moving chains triggered by market-rate and social housing buildings. Our main interest lies in whether new and expensive market-rate buildings trigger moving chains that reach middle- and low-income neighborhoods and individuals (defined as bottom-half and bottom-quintile of the income distribution), but we also report respective shares for the top-quintile for comparison.

Starting with neighborhoods, Figure 4a shows that roughly 50% of new market-rate building residents originate from neighborhoods classified in the bottom half of the neighborhood income distribution. This share gradually rises to around 70% by round three, when it flattens. We expect it to flatten at roughly 70% since the overall share of all movers from the first five deciles cumulates to this amount (see Figure A3).

Figure 4: Origin neighborhood and individual characteristics for movers at each round



(a) Market-rate, zip codes

(b) Social housing, zip codes

(c) Market-rate, 250m grids

(d) Social housing, 250m grids

(e) Market-rate, individuals

(f) Social housing, individuals

Notes: The left panel shows the share of movers originating from the HMA at each round when the first round destination building is market-rate. The right panel shows the corresponding shares when the first round destination building is social housing.

The share of residents originating from the bottom quintile zip codes is 10-15% depending on the neighborhood division. The share is higher when using the zip code

division and increases only slightly when we move to further rounds. This is somewhat surprising and potentially due to zip codes containing different types of smaller neighborhoods. That is, the movers from the bottom zip code quintile may be those living in the highest quality parts of the zip codes and may have the highest incomes in these zip codes. If so, the zip code level analysis would overstate the extent that new buildings loosen low-income housing markets.

This interpretation is consistent with Figure 4c, which depicts origin neighborhoods based on 250 square meter grids. The share of residents originating from the bottom quintile grids is only 10% and the share increases gradually in subsequent rounds reaching 30% by rounds five and six.

A similar, albeit steeper increasing pattern can be observed when movers are classified into deciles based on household income at the national level (Figure 4e). Only 20% (10%) of new market-rate building residents are from the bottom-half (bottom-quintile) of the national household income distribution, but this share reaches roughly 50% (30%) by round five. Taken as a whole, new and expensive market-rate buildings trigger moving chains that reach middle- and low-income housing markets and households even in the short run.[10]

These patterns echo those reported by Mast (2021) in US CBSAs, but some interesting differences emerge. The most striking difference is that in our case the shares of moves from the bottom-half and bottom-quintile in each round are higher compared to the US case. That is, the moving chains are more likely to reach middle- and low-income neighborhoods and reach them faster in our case. The difference may be partly driven by differences in the data and methodology used to construct moving chains, but they probably also reflect differences in income inequality and residential segregation between US cities and the HMA. This would mean that the socio-economic distance between expensive and low-income neighborhoods is smaller in the HMA compared to US cities. The price differences between neighborhoods are also likely to be smaller.

Another interesting point of comparison for market-rate buildings is rent-controlled social housing. In Figures 4b, 4d and 4f we show the results for moving chains triggered by new social housing buildings. The main difference between market-rate and social housing emerges in the first few rounds where the share of moves coming from the bottom-half and bottom-quintile are higher. Thus, social housing buildings loosen the middle- and low-income housing markets more directly, but this comes with considerable costs to taxpayers due to forgone rental income (see Eerola and Saarimaa 2018).[11] This is consistent with the interpretation made above that moving chains reach middle- and low-

[10]Figure A4 reproduces the numbers for bottom- and top-deciles and the patterns are similar.

[11]In brief, the costs arise as most of the social housing buildings are situated on lots owned by the city of Helsinki and lot rents collected by the city are well under market rents.

income neighborhoods faster when the price difference between the city's core and other neighborhoods is smaller.

4.4 Probability of the moving chain to reach certain submarkets

Another way to illustrate how often a moving chain reaches a particular sub-market or includes particular types of individuals is to calculate the probability that a chain reaches a particular sub-market or group of individuals. When this is done at the neighborhood level, one interpretation for this probability is that it gives the number of new effective units in that sub-market created through vacancies (see also Mast 2021).

We obtain these probabilities through the following exercise. For each unique round 1 destination-origin unit pair, we reconstruct the chain of origin units from subsequent rounds.[12] We restrict to unique round 1 destination-origin unit pairs because multiple individuals may move to the same destination from the same origin (e.g. members of the same household changing homes). We therefore effectively collapse individuals to the household-level.[13] This gives us 4,473 observations corresponding to 2,939 new market-rate destination units. Note that we may have multiple observations per destination unit. This happens when, at some point in the chain, there are moves from different origin units, due most likely to household formation. For each of the 4,473 observations, we construct a dummy that takes the value 1 if at least one origin unit or household in the chain (out of the possible six) is ranked in the bottom half or bottom quintile of the median disposable income distribution. We take the average of this dummy variable across all observations within the same new destination building. As long as it is above zero, we conclude that the chain triggered by that new destination building includes a lower-income neighborhood or household. Finally, we take an average of the collapsed dummy variable. We report these averages in Table A1.

In sum, the probability that a chain reaches zip codes in the bottom quintile (bottom half) of the income distribution is about 29% (60%). That is, for each 100 new, centrally located market-rate units, 29 units get created through vacancy in bottom-quintile income zip codes and 60 units in bottom-half income zip codes. When we instead define sub-markets at the grid-level, these numbers are 26 and 61, respectively. Table A1 summarizes the results for both market-rate units and social housing units.

[12] About 27% of chains triggered by new-market housing end after just one round (see Figure A5).
[13] Of course, a household may consist of only one individual as well.

5 Conclusions

We have analyzed the city-wide effects of new market-rate construction using geo-coded register data from the Helsinki Metropolitan Area. We show that even when new market-rate units get occupied by high-income households, they also benefit middle- and low-income households through a moving chain mechanism.

These results are important for the policy debate in many cities about the merits of increasing the supply of market-rate housing. As, for example, Been et al. (2019) argue, skepticism surrounding the connection between housing supply and affordability has been growing and one of the main concerns is that market-rate supply benefits only the better-off. Our results, together with the results by Mast (2021) for US cities, should alleviate the concerns of these skeptics. As geo-coded register data become available in other countries, replication of our study and comparing the results to ours and to those by Mast (2021) will help to further shed light on the type of contexts where new market-rate supply is most likely to benefit lower-income households.

Finally, we stress that while market-rate housing supply seems to have wide-ranging beneficial effects, it is not a panacea for all housing market problems. Some people may get discriminated out from the housing market and for some others even the cheapest housing in the city may not be affordable. Housing allowance or voucher programs, as well as social housing are important complements to market-rate supply. These programs, if well-designed, may also be helpful in preventing residential segregation (e.g., Collinson and Ganong 2018 and Davis et al. 2021).

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Online Appendix: Additional figures and tables

Figure A1: Number of new buildings in the sample

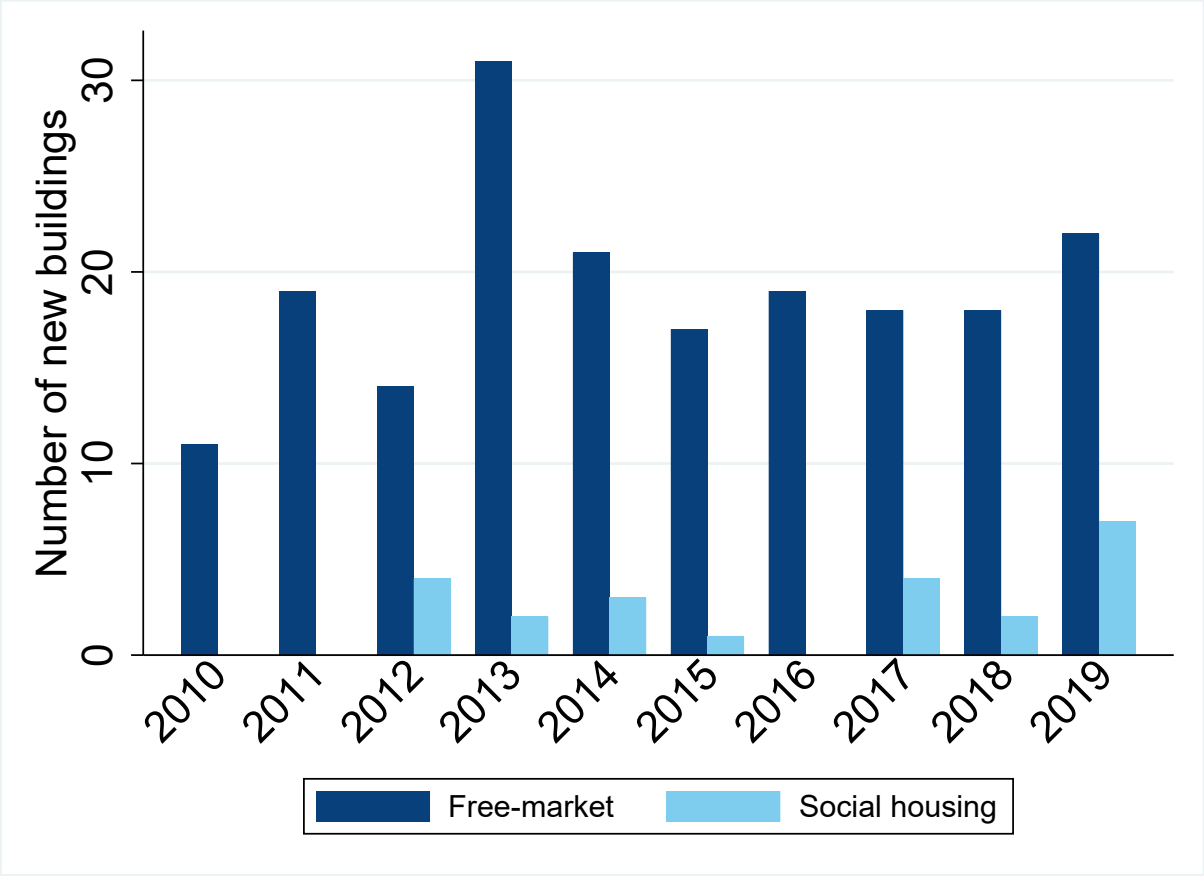
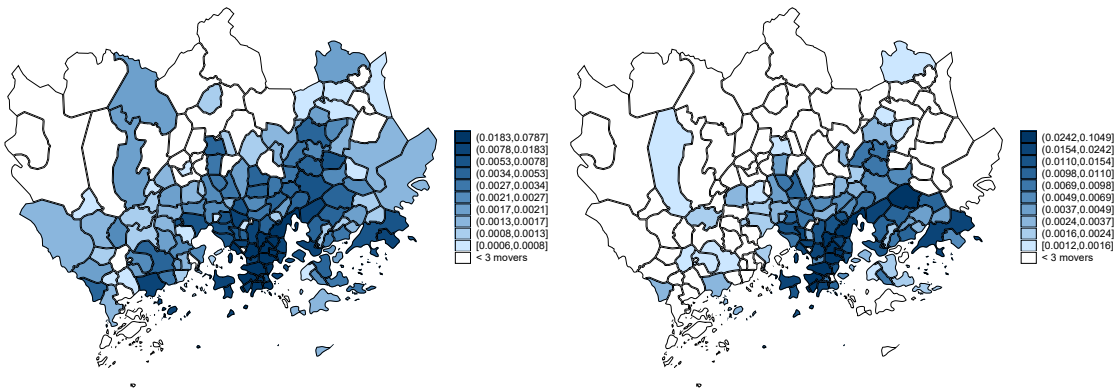


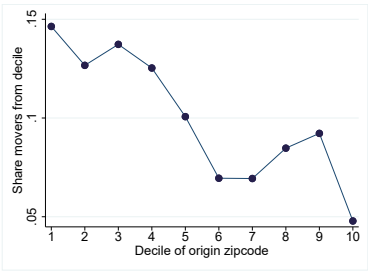
Figure A2: Origin neighborhoods of first round movers



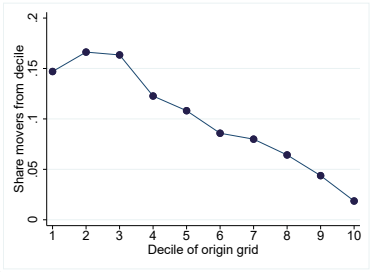
(a) Market-rate units (b) Social housing units

Notes: The figure depicts the share of movers to new buildings from each HMA zipcode.

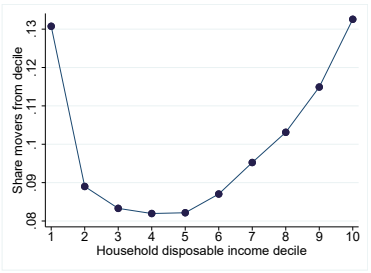
Figure A3: Share of movers by neighborhood decile



(a) Share movers by zip code decile



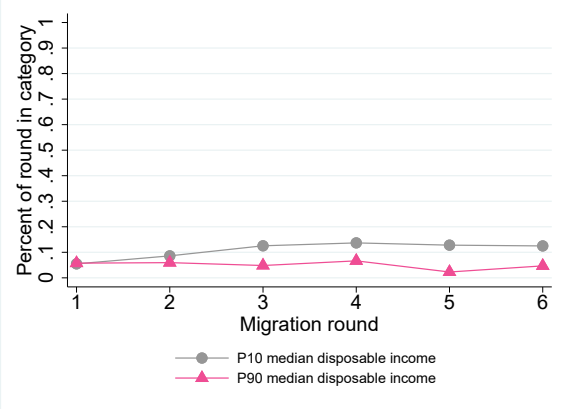
(b) Share movers by grid decile



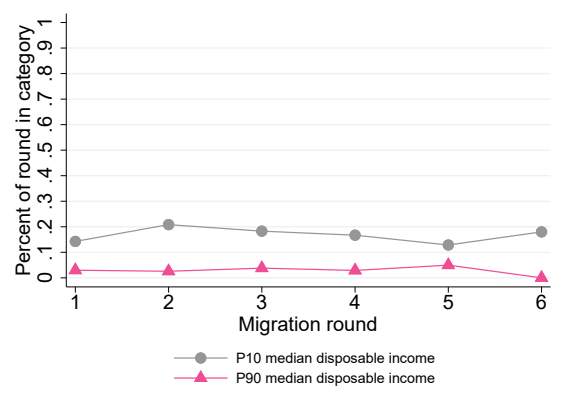
(c) Share movers by household income decile

Notes: The figure depicts the share of movers out of all movers during the 2010-2019 time period in the respective decile. The shares in each subfigure sum up to one.

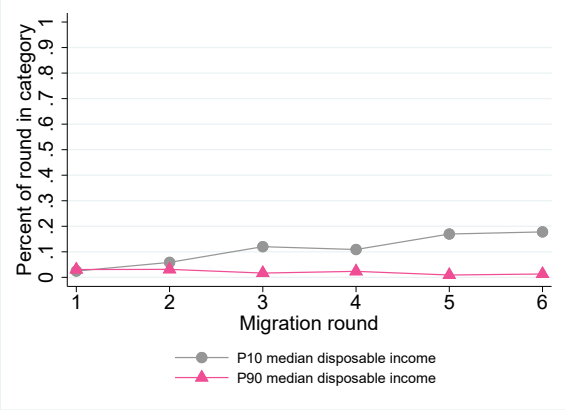
Figure A4: Origin neighborhood characteristics for movers at each round



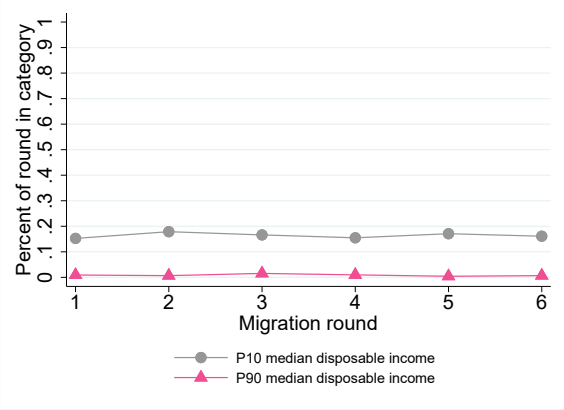
(a) Market-rate, zip codes



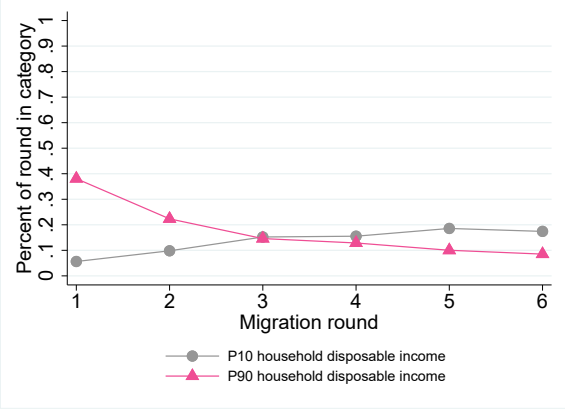
(b) Social housing, zip codes



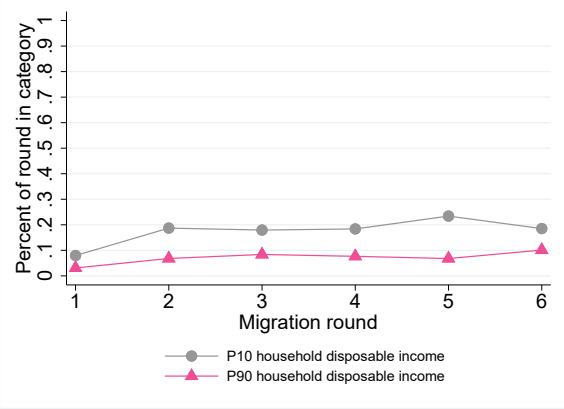
(c) Market-rate, 250m grids



(d) Social housing, 250m grids



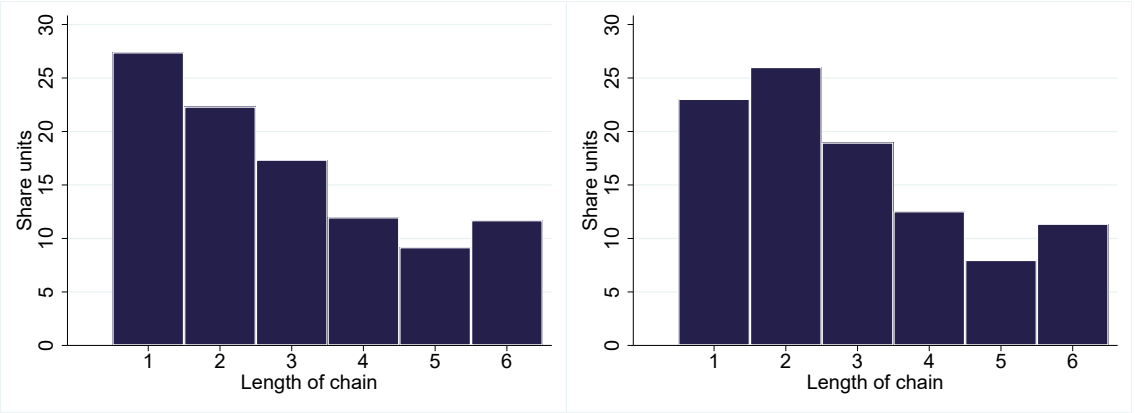
(e) Market-rate, individuals



(f) Social housing, individuals

Notes: The left panel shows the share of movers originating from the HMA at each round when the first round destination building is market rate. The right panel shows the corresponding shares when the first round destination building is social housing.

Figure A5: Chain length



(a) Market-rate units (b) Social housing units

Table A1: Probability of chain reaching lower-income submarkets and households

	Market-rate units	Social housing units
P20 zip codes	0.287	0.432
	[0.453]	[0.496]
P50 zip codes	0.599	0.753
	[0.490]	[0.431]
P20 grids	0.263	0.509
	[0.440]	[0.500]
P50 grids	0.611	0.808
	[0.488]	[0.394]
P20 households	0.362	0.454
	[0.481]	[0.498]
P50 households	0.554	0.739
	[0.497]	[0.439]

Notes: P20 refers to the bottom quintile of the income distribution and P50 refers to the bottom half of the income distribution. Standard deviations are reported in brackets.