

Sevrin Waight*

Gentrification and displacement in English cities*

Abstract: This paper uses the British Household Panel Survey (1991-2008) and the UK Census (waves 1991, 2001 and 2011) to examine whether gentrification of neighbourhoods in English cities leads to displacement of the original residents. Gentrification is the phenomenon of a large and relatively sudden in-migration of wealthy or middle class residents into a previously poor or working class neighbourhood. I use the change in the share of neighbourhood population that holds a degree certificate as a measure of the pace of gentrification. I relate this measure of gentrification to neighbourhood exits at the household level. My empirical strategy aims to control for differences in natural mobility rates due to the sorting of households across different neighbourhoods. I take several steps to deal with this issue such as estimating a neighbourhood fixed effects model and interacting of the gentrification treatment with household characteristics that indicate vulnerability to displacement. The findings indicate that gentrification is associated with significant displacement of low income (private) renters especially in the early stages of the process. These are the first estimates of displacement for English cities and the first to estimate the effect at different stages of gentrification and at different income levels. The evidence presented here is contradictory to the prevailing evidence on displacement and is more consistent with the theoretical understanding of gentrification as process of outbidding.

Keywords: Gentrification, Displacement, Neighbourhood change, Residential mobility

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* London School of Economics and Political Science, Department of Geography and Environment & What Works Centre for Local Economic Growth, Houghton Street, London WC2A 2AE, s.g.waights@lse.ac.uk.

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1 Introduction

Gentrification is the phenomenon of a large and relatively sudden in-migration of wealthy or middle class residents into a previously poor or working class neighbourhood. Following the suburbanisation of previous decades, gentrification marks the most recent major trend in the history of cities in industrialised countries. Gentrification is also a very controversial topic. For example, Lees et al. (2013) refer to the phenomenon as a “battleground in urban geography”. The proponents of gentrification refer to it as urban revitalisation and consider it the reversal of ‘white flight’ and urban decay. In support of this view is a literature on neighbourhood effects that suggests economic outcomes of households may be improved by living in neighbourhoods with overall better outcomes (e.g. Buck, 2001). As such, certain types of policy attempt to actively gentrify neighbourhoods, sometimes by making physical improvements to the dwelling stock (e.g. Housing Market Renewal in the UK). The opponents of gentrification, however, suggest that if the original residents are displaced then they are not able to benefit from any neighbourhood effects that do exist¹. Displacement itself represents a huge cost to the displaced households (Slater, 2009) and original residents that remain in the neighbourhood may feel alienated by the changes to neighbourhood’s character (Lees et al., 2010).

The issue of displacement is central to the debate, and whether gentrification displaces original residents drastically changes how the phenomenon should be viewed and dealt with by policy. If residents are displaced then it becomes difficult to motivate policies that actively gentrify neighbourhoods with the suggestion that they are beneficial for original residents. Furthermore if the negative consequences of gentrification are to be avoided then policies should aim to provide more social protection for incumbent residents.

Whilst gentrification is an important recent trend, whether it actually causes displacement remains an open question. In fact, research on the effects of gentrification is characterised by a theoretical-empirical divide. The theoretical literature in urban economics describes gentrification as a process of outbidding (Brueckner & Rosenthal, 2009; Brueckner et al., 1999). An increase in amenities or preferences of a rich group for an urban neighbourhood leads to a shift in the bid rent to above what the poor group are willing and able to pay. The poor group are outbid and must relocate to the periphery in a large scale displacement. However, the (small) empirical evidence to date finds no evidence of displacement (Freeman, 2005; Freeman & Braconi, 2004; McKinnish et al., 2010; Vigdor et al., 2002). By examining exit rates in

¹ In fact, the emerging evidence from field experiments that shows households do not benefit from living in wealthier neighbourhoods (Ludwig et al., 2013; Oreopoulos, 2003).

gentrifying neighbourhoods compared with non-gentrifying neighbourhoods this literature finds that low-status households are not more likely to exit under gentrification.

This paper provides new evidence on the question of whether gentrification leads to displacement. I use the British Household Panel Survey (1991-2008) and the UK Census (1991, 2001 and 2011) to examine the association between gentrification and displacement in English cities. I use the change in degree share to capture different speeds of gentrification and interact this with the initial degree share to capture effects at different stages of gentrification. I relate this measure of gentrification to neighbourhood exits at the household level. I argue that previous estimates of displacement deal unsatisfactorily with differences in natural mobility rates due to the sorting of households across different neighbourhoods. My empirical strategy takes several steps to deal with these unobserved differences, including the estimation of a neighbourhood fixed effects model and the interaction of the gentrification treatment with household characteristics that indicate vulnerability to displacement. In particular I compare renters with homeowners and private renters with social renters. These interactions help compare exit rates of affected with unaffected groups to isolate the displacement effect. The findings indicate that gentrification is associated with significant displacement of low income renters especially in the early stages of the process. The displacement effect is shown to be greatest for private renters.

This paper makes several contributions to the literature. The estimates presented here are the first robust evidence on displacement for English cities and the first to estimate displacement effects at different stages of gentrification and at different income levels. The empirical strategy makes several improvements over the existing literature. Finally, the evidence presented here is contradictory to the prevailing evidence on displacement and is more consistent with the theoretical understanding of gentrification as a process of outbidding (e.g. Brueckner and Rosenthal 2009).

This research is relevant to a number of areas of the literature. It contributes directly to the literature that estimates the displacement effect of gentrification (Freeman, 2005; Freeman & Braconi, 2004; McKinnish et al., 2010; O'Sullivan, 2005; Vigdor et al., 2002) and that on broader empirical issues related to gentrification (e.g. Ahlfeldt, 2011; Bostic & Martin, 2003; Ellen & O'Regan, 2008; Helms, 2003; Vigdor, 2010). It also relates to the theoretical literature that describes gentrification (e.g. Brueckner & Rosenthal, 2009; Brueckner et al., 1999; Guerrieri et al., 2013; O'Sullivan, 2005; Rosenthal, 2008) and patterns of residential income segregation (e.g. Glaeser et al., 2008; LeRoy & Sonstelie, 1983; Tivadar, 2010; Wheaton, 1977). Finally it contributes, particularly from a policy standpoint, to the literature that evaluates physical regeneration efforts (e.g. Collins & Shester, 2013; Richter et al., 2013). The paper structure is as

follows. Section 2 reviews the existing empirical literature on the displacement question, highlighting key empirical challenges and results. Section 3 outlines the BHPS and UK census data used in this analysis. In section 4 I construct the empirical strategy with a focus on addressing mobility differences. Section 5 presents the results and section 6 concludes with some policy recommendations.

2 Empirical Literature

Empirical studies on whether gentrification is associated with displacement typically define gentrification based on increases in neighbourhood income or educational attainment. It is then examined whether there is a statistical relationship between this measure and the mobility rates of existing residents. Freeman (2005) points out that earlier studies tended to suffer from methodological flaws such as failing to include in the analysis a counterfactual group of neighbourhoods that did not gentrify i.e. examining only time variation for neighbourhoods that did gentrify. This means that it is impossible to tell whether the observed displacement rates in gentrifying neighbourhoods is in fact any higher than the rate in non-gentrifying neighbourhoods. Freeman (2005) and Vigdor et al. (2002) both provide good reviews of these early empirical studies. In this literature review I focus on four of the most recent studies that are the most methodologically robust. These are Vigdor et al. (2002), Freeman and Braconi (2004), Freeman (2005) and McKinnish et al. (2010). From this review I will identify both key results, particularly regarding whether gentrification leads to displacement, and key empirical issues such as important control variables and identification strategies.

Typically, studies into gentrification and displacement make use of two data sources. One for households that gives a dependent variable relating to exit or mobility rates, and one for neighbourhoods that allow for characterising gentrification, usually in terms of income growth or educational attainment growth. Vigdor et al. (2002), for example, make use of the American Housing Survey (AHS) for 1985-89 and 1989-93 and the Public Use Microdata Sample (PUMS) for the Census (1980-1990). The dependent variable is whether a housing unit from the AHS still holds the same household at the end of the period that it did in the beginning. Gentrification is then defined as neighbourhoods that experience an increase in the share of population that hold a degree of more than 50% above the average for the Metropolitan Statistical Area (MSA).

The mobility variable is then regressed on the gentrification variable usually in either a logit or a probit model. This empirical strategy² is intended to address the difficulty involved with showing actual displacement rather than simply mobility. If it can be shown that the mobility rates are higher in the gentrifying neighbourhoods than in the other neighbourhoods, and that the higher rates can be attributed directly to the gentrification, then this can be taken as evidence for displacement. The important caveat is that it must be shown that the higher rates are due to the gentrification and not to other factors that may be different between

² Vigdor et al. (2002) was one of the first empirical studies on gentrification and displacement to compare mobility rates in gentrifying neighbourhoods to a counterfactual group of non-gentrifying neighbourhoods.

neighbourhoods. Neighbourhoods that gentrify are likely to be different from neighbourhoods that do not gentrify, for example, they may have fewer social housing units. Social housing units have different characteristics to other units that will directly affect the exit rates of the households that live in them. Also, different housing characteristics will attract different types of individuals who have different baseline mobility rates. Therefore a lower exit rate in a non-gentrifying tract may not be directly related to the fact that the neighbourhood is not gentrifying but to something else entirely, such as the proportion of social housing in that neighbourhood.

Important controls for differences in householder characteristics are things such as age, education, income, tenure, number of years at current residence, ethnicity, nationality, marital status and employment status. Household and neighbourhood characteristics that have been shown to be important factors related to mobility are household size (particularly in relation to number of rooms), maintenance deficiencies, rent subsidies, rent control, public housing complexes and vacancy rates (Vigdor et al. 2002, Freeman and Braconi 2004, Freeman 2005). Vigdor et al. (2002) also controlled for the householder's own rating of the neighbourhood and particular housing unit they live in.

Another important empirical issue is to compare gentrifying neighbourhoods to similar neighbourhoods that did not gentrify. Vigdor et al. (2002) and Freeman and Braconi (2004) control for various household characteristics, but they compare mobility in gentrifying neighbourhoods to mobility in all other neighbourhoods. On the other hand, Freeman (2005) and McKinnish et al (2010) provide more plausible counterfactuals by first selecting a sample of neighbourhoods that might have potentially undergone gentrification and then comparing the ones that did to the ones that didn't. For Freeman (2005) the neighbourhoods must be central city areas, with a comparatively (compared to MSA median) low median income and a comparatively low share of housing built in the last 20 years. The gentrifying neighbourhoods are then the ones that experienced a comparatively large increase in educational attainment and an increase in real housing prices. For McKinnish et al. (2010) the potential neighbourhoods must be both urban and in the bottom quintile in terms of median household income. The gentrifying ones are defined as those that experience at least a \$10,000 dollar increase in mean household income.

A further issue is that unit of analysis. If *households* are observed, as in Freeman (2005), it is possible to examine whether they exit the neighbourhood that is gentrifying. However, if *housing units* are observed (Vigdor et al. 2002, Freeman and Braconi, 2004) then it is only possible to say if the household left the unit and nothing about how far it went. This makes it impossible to tell whether the household actually exited the area that is gentrifying. Hence, the

claim that empirical analysis is testing the relationship between gentrification and displacement is made weaker by this fact. Finally, McKinnish et al. (2010) only use one data source (confidential US Census data) to characterise both exits and gentrification. As a result they are neither able to say where households move to, or in fact, whether any specific household has moved at all. Instead they use a less reliable cohort analysis that looks at the populations and characteristics of individuals who report to have stayed in the neighbourhood for at least ten years compared to groups from the previous census with similar characteristics who are ten years younger, with the intention that they are the same people. Thus when they find that the income of a particular group tends to increase more in gentrifying neighbourhoods than in non-gentrifying neighbourhoods they are not able to say whether this is because the households toward the lower income distribution in this group left the area or because there has been a general increase in income across all the households of this group.

Also important is the size of the areas used to classify gentrification. In the two earlier papers by Vigdor et al. (2002) and Freeman and Braconi (2004), the areas used are too large to be referred to as neighbourhoods. Vigdor et al. (2002) look at AHS Zones in Boston, which are of around 100,000-200,000 people in size. The city of Boston itself is made up of only 5 zones. Freeman and Braconi (2004), in their study of New York also use areas of around 100,000 in population. These large areas are problematic for several reasons. Gentrification is an urban phenomenon but since there were only 5 areas for the city of Boston, Vigdor et al. (2002) are forced to expand his analysis to the surrounding suburbs and county in order to make sufficient sample size. Even including these, the spatial variation in the gentrification variable is rather coarse. In Vigdor et al.'s (2002) 'exclusive' definition, only one area is defined as gentrifying and in his 'inclusive' definition there are only a few more. Freeman and Braconi (2004) have only seven gentrifying areas (selected using anecdotal evidence) from a total of 55 areas. Since gentrification is a highly localised phenomenon, using large areas means that for any household the gentrification indicator for their area may not be a very reliable reflection of whether they are in a gentrifying neighbourhood or not. Also, these aggregate areas have important implications for the standard errors of the estimates, that should be clustered at the area level (this was correctly implemented only by McKinnish et al. 2010). Finally, using smaller areas allows for a more precise indication of whether a household move actually exits the area that is gentrifying (if one is using a household survey). Freeman (2005) and McKinnish et al (2010) both use much smaller Census tracts of around 1,000-8,000 people and their samples also cover the whole of the US.

Before turning to review the results of these papers, I examine one last empirical issue that is the conditioning of the gentrification effect on other factors. It is not sufficient to add as controls the factors that are thought to have a significant effect on the relationship between

gentrification and displacement. For example in gentrifying areas, particular groups such as renters or the low income may be more susceptible to being displaced than other groups. Homeowners are protected from the escalation of rent prices that accompanies gentrification and an increase in the price of their home brings no extra costs until the point of sale³, where the costs will only represent a fraction of the overall benefits associated with selling at a higher price. Hence the gentrification variable can be interacted with various household characteristics to reveal conditional effects. Vigdor et al. (2002) look at the effect conditional on educational attainment (high school diploma) of the head of household. Freeman and Braconi (2004) do not estimate an interacting variable but restrict their sample to either low income or low education householders. Freeman (2005) looks at the effect for a group defined as ‘poor renters’, who have both a low income and are renters.

The results of the papers I examine here generally find no evidence of displacement as a result of gentrification. Vigdor et al. (2002), in fact, find after introducing controls that households are *more likely* to stay in their housing unit if they live in gentrifying areas in Boston. In another specification they find this to be true only for low educated householders. There is no evidence found for displacement for any group. Freeman and Braconi (2004) for New York in the 1990s also find slower residential turnover for poor and less educated households in areas that are undergoing a process of gentrification compared to other areas. Freeman (2005) is the only paper in this review that does find evidence for displacement, but not a significantly higher effect for the poor renter group. Finally, McKinnish et al. (2010) do not claim to find evidence for displacement although admit that there is some ambiguity in the interpretation of their results due to the methods used. The overall empirical evidence is not in favour of gentrification being associated with displacement. However, the analyses do have a lot of empirical problems and therefore something new may be learned from an analysis that improves in the highlighted areas. Also, the paper that appear to suffer the least from methodological issues, Freeman (2005), does find some evidence for displacement suggesting that there may indeed be an effect.

Table 1 below also provides a summary of the literature I have reviewed here in terms of all the important aspect identified. I will now recap the important issues learnt from the review of the literature and therein lay out the criteria that this paper should meet. Firstly, the analysis must include appropriate household and neighbourhood control variables. This paper therefore matches the controls used in all the previous paper and adds some further controls. The identification strategy in general will be improved by implementing ward fixed effects. This

³ In the UK, a tax called stamp duty is applied at the point of sale and represents a percentage of the transaction price. There are no increased costs in terms of tax assessment associated with owning a property of a higher value; therefore, there is no displacement pressure on low income homeowners in gentrifying areas.

specification will eliminate the unobservable bias due to fixed difference in wards by estimating the displacement using only time variation in gentrification in each ward. Secondly, the areal unit must be sufficiently small. Hence I will work with Census wards, which have a population of around 6,000-7,000 and are roughly comparable to smallest neighbourhoods used in previous analyses. Thirdly, it is best to work with household data. Hence I use the BHPS to identify household exits from neighbourhoods over the period 1991-2008. Fourthly, it is important to identify an appropriate control group of potentially gentrifying neighbourhoods. I intend to build on this further by introducing a flexible definition of gentrification that compares the effect of increases in degree share conditional on the initial level of degree share. This is advantageous in that it measures the effect with respect to the magnitude of the gentrification (rather than a binary variable) and also conditions the effect on how gentrified the neighbourhood is already. Fifthly, further interacting relationship may yield interesting insights and help control for unrelated differences in mobility rates. I therefore intend to interact the main relationship with both tenure and income as well and tenure interacted with income. In the next section I examine the data that will be used in the analysis.

Table 1: Review of literature

	Vigdor (2002)	Freeman and Braconi (2004)	Freeman (2005)	McKinnish et al. (2010)
Case	Boston (1985-93)	New York City (1991-1999)	U.S. (1986-1998)	U.S. (1990-2000)
Regression type	Probit	Logit	Logit	Logit
Households data	1. American Housing Survey (AHS)	1. NYC Housing Vacancy Survey (NYCHVS)	1. Panel Study of Income Dynamics (PSID)	(Cohort analysis)
Neighbourhoods data	2. Public Use Sample (PUMS)	(Gentrifying areas selected anecdotally)	2. U.S. Census	2. U.S. Census
Unit of observation	Housing unit	Housing unit	Heads of households	Synthetic cohorts
Dependent variable	Binary variable: Same household in unit at end of period	Binary variable: Same household in unit at end of period	Binary variable: Two alternatives (binary): Displaced	Binary variable: Two alternatives: Population change
Neighbourhoods	AHS Zone (100,000-200,000)	Community Districts (46,000)	Census Tracts (1,000-8,000)	Census Tracts (1,000-8,000)
Neighbourhood sample	All areas	All areas	Must be all of: 1. Central City 2. Low income 3. Old housing	Must be all of: 1. Urban 2. Low income
Gentrification variable	Two alternatives (binary): 1. 'Exclusive' - from Wyly and Hammel (1990) 2. 'Inclusive' - increase in education	Binary variable chosen based on familiarity with areas	Two alternatives (binary): 1. increase in education 2. increase in real house prices	Binary variable: \$10,000 increase in household income

Review of literature (continued)

Conditional relationships	High school diploma	Poor and Non-college grad (restricted samples)	Poor renters	Ethnicity x Education x Age
Controls	Age High school diploma Income Own house rating Own neigh rating Owner Public complex Rent control Subsidized	Age Education Employment Ethnicity Income Maintenance deficiencies Marital Native Neighbourhood rating Other regulation Overcrowded Rent-controlled Rent-stabilised Sex Year Years in residence	Age Assisted Housing Education Employment Ethnicity Household composition Immigrant Income Marital status Region /Year Renter Sex Unit crowded Vacancy rate Years in residence	CSMA fixed effects Lag of tract income Marital status Marital status x race Immigrant Immigrant x race race
Main findings	Less educated householders <i>more likely</i> to stay in unit if in gentrifying areas.	Low income and less educated are less likely to exit gentrifying areas than other areas.	Displacement occurs but not at a higher rate for poor renters.	No evidence for displacement.

3 Data

The data used in this study come from two sources; the British Household Panel Survey (BHPS) and the UK Census (1991, 2001 and 2011). The UK Census is conducted decennially for the entire UK population. The Census is used in this study to characterise the extent of gentrification in neighbourhoods using 10-year changes in the share of individuals in a census ward that hold degree certificate or higher. Further, the UK Census will provide some of the ward level control variables for the analysis. The BHPS is a longitudinal survey of households that was conducted annually for 18 waves (1991-2008). It provides home location identifiers as well as a very rich set of household characteristics. Head of household-years are the unit of analysis for this paper and whether or not they exit their neighbourhood is the outcome variable. Household heads must be observed one period ahead in order to know if they exited their neighbourhood or not. Because of this, exits cannot be observed in the last wave of the BHPS (2008). The BHPS household-years will be merged with the census data at the neighbourhood (CAS Ward) level, with BHPS observations from 1991-2000 being merged with changes over the intercensal period 1991-2001 and BHPS observations from 2001-2007 with the intercensal period 2001-2011.

3.1 Gentrifying neighbourhoods (UK Census)

In order to characterise neighbourhoods in terms of their gentrification status I use the share of population that holds a degree, provided by the UK Census. Educational status has been used in previous literature to measure gentrification, along with measures of income. However, educational attainment is a more stable personal characteristic than income and therefore serves as a more reliable measure of inflow of different demographic group rather than simply changes in the characteristics of existing groups. The degree share variable was obtained from the 1991, 2001 and 2011 Censuses at the ward level. The exact ward definitions differ from census to census and so the figures were converted to comparable geographical units using conversion tables. The resulting data are defined according to the 2001 Census Area Statistics (CAS) Wards for which there are 7,969 covering England. These wards have an average population of 6,669 individuals and an average size of 16.7km². These are more suitable for an analysis at the neighbourhood level than the more aggregated areas (over 100,000 people) used in similar studies (Vigdor 2002, Freeman and Braconi 2004). They are comparable to more recent studies that make use of non-public census data⁴ for the US (McKinnish et al. 2010 and Freeman 2005).

⁴ They use US Census tracts with populations between 1,000 and 8,000 people.

Table 2: Wards by initial degree share quintiles (1991-2001)

Quintile	N	Mean	Min	Max
1 st	1,593	0.256	0.203	0.599
2 nd	1,594	0.178	0.155	0.203
3 rd	1,594	0.134	0.114	0.155
4 th	1,594	0.096	0.076	0.114
5 th	1,594	0.052	0.005	0.076
Total	7,969	0.143	0.005	0.599

Table 3: Wards by initial degree share quintiles (2001-2011)

Quintile	N	Mean	Min	Max
1 st	1,594	0.344	0.271	0.725
2 nd	1,594	0.239	0.211	0.271
3 rd	1,594	0.186	0.163	0.211
4 th	1,593	0.139	0.114	0.163
5 th	1,594	0.088	0.031	0.114
Total	7,969	0.199	0.031	0.725

Table 4: Wards by change in degree share quintiles (1991-2001)

Quintile	N	Mean	Min	Max
1 st	1,593	0.127	0.084	0.590
2 nd	1,594	0.069	0.056	0.084
3 rd	1,594	0.047	0.039	0.056
4 th	1,594	0.031	0.023	0.039
5 th	1,594	0.005	-0.358	0.023
Total	7968	0.056	-0.358	0.590

Table 5: Wards by change in degree share quintiles (2001-2011)

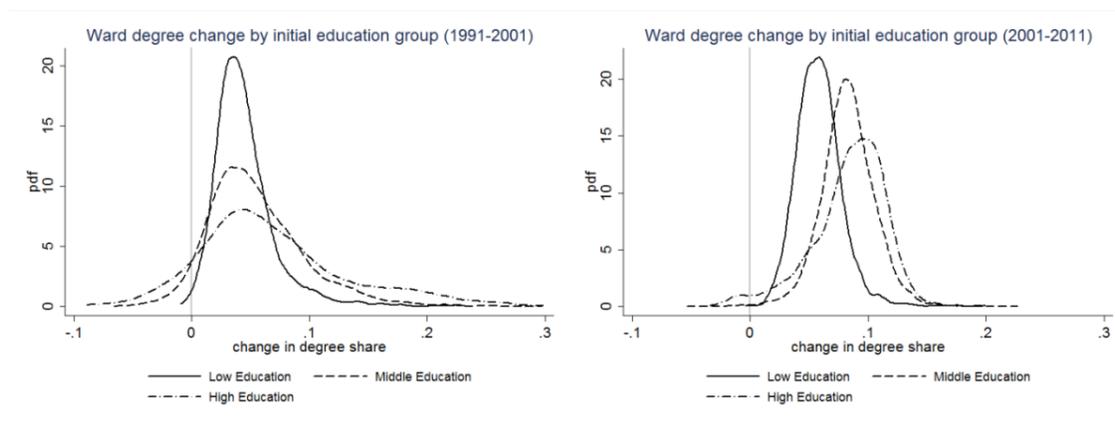
Quintile	N	Mean	Min	Max
1 st	1,594	0.114	0.100	0.227
2 nd	1,594	0.092	0.085	0.100
3 rd	1,594	0.079	0.072	0.085
4 th	1,593	0.065	0.057	0.072
5 th	1,594	0.041	-0.118	0.057
Total	7969	0.078	-0.118	0.227

Gentrifying wards are those that have a low initial degree share followed by a large over the intercensal period (1991-2001 or 2001-2011). Table 2 and Table 3 illustrate the initial degree share variable by quintiles for the two intercensal periods. The initial degree share for 2001-2011 has a higher mean, min and max in every quintile and in total than for 1991-2001. This is consistent with a general 'upgrading' of human capital in England over the period 1991-2011. Further the tables illustrate that degree shares in 1991 range from 0.5% to 59.9% with a mean

of 14.3% and in 2001 range from 3.1% to 72.5% with a mean of 19.9%. The intercensal change in degree share is given in Table 4 and Table 5. Again, 2001-2011 has the highest mean (a 7.8% increase compared with a 5.6% increase over 1991-2001) but it does not have the highest max (only 22.7% compared with 59.0%). There are some wards in both periods that experienced large decreases in degree shares. An urban/rural indicator, introduced in 2004 by the Rural Evidence Research Centre at Birkbeck College (RERC), was obtained at the ward level for England. Urban wards were then selected as those that belong to a settlement with a population of over 10,000.

Next I examine how the change in degree share varies across wards with different initial degree shares. Figure 1 shows more highly educated wards tend to have larger increases in degree share than less educated wards. This correlation is stronger in the second decade than in the first. The variance in change in degree share is also much larger for the more educated wards.

Figure 1: Kernel density plots of degree change by initial degree group



Finally, Figure 2 below illustrates the wards for England and whether they are urban, low education or gentrifying. The categories used in this map are based on the quintiles and are therefore fairly arbitrary. The map is merely intended to give a general overview of the spatial pattern of gentrification in England and a more flexible definition will be used in the empirical analysis. The map shows a few things. Firstly, the low income neighbourhoods are more concentrated in the centre of each urban area with London being a significant exception. Secondly, gentrification begins (in the 90s) in the most central of these low income neighbourhoods and then (in the 00s) spreads out to the next most central low income neighbourhoods. Thirdly, there are very few wards that gentrify in both periods. This is because, due to the way gentrification has been defined here, if a ward gentrifies in the first period it is highly likely to be a non-low education ward and so cannot gentrify again in the second period. The observed pattern of concentric waves of gentrification spreading out from the urban centres is consistent with the model proposed by Brueckner and Rosenthal (2009). This pattern

can also explain why there are no low education wards in the centre of London, if it is that gentrification started long before the 90s in central London.

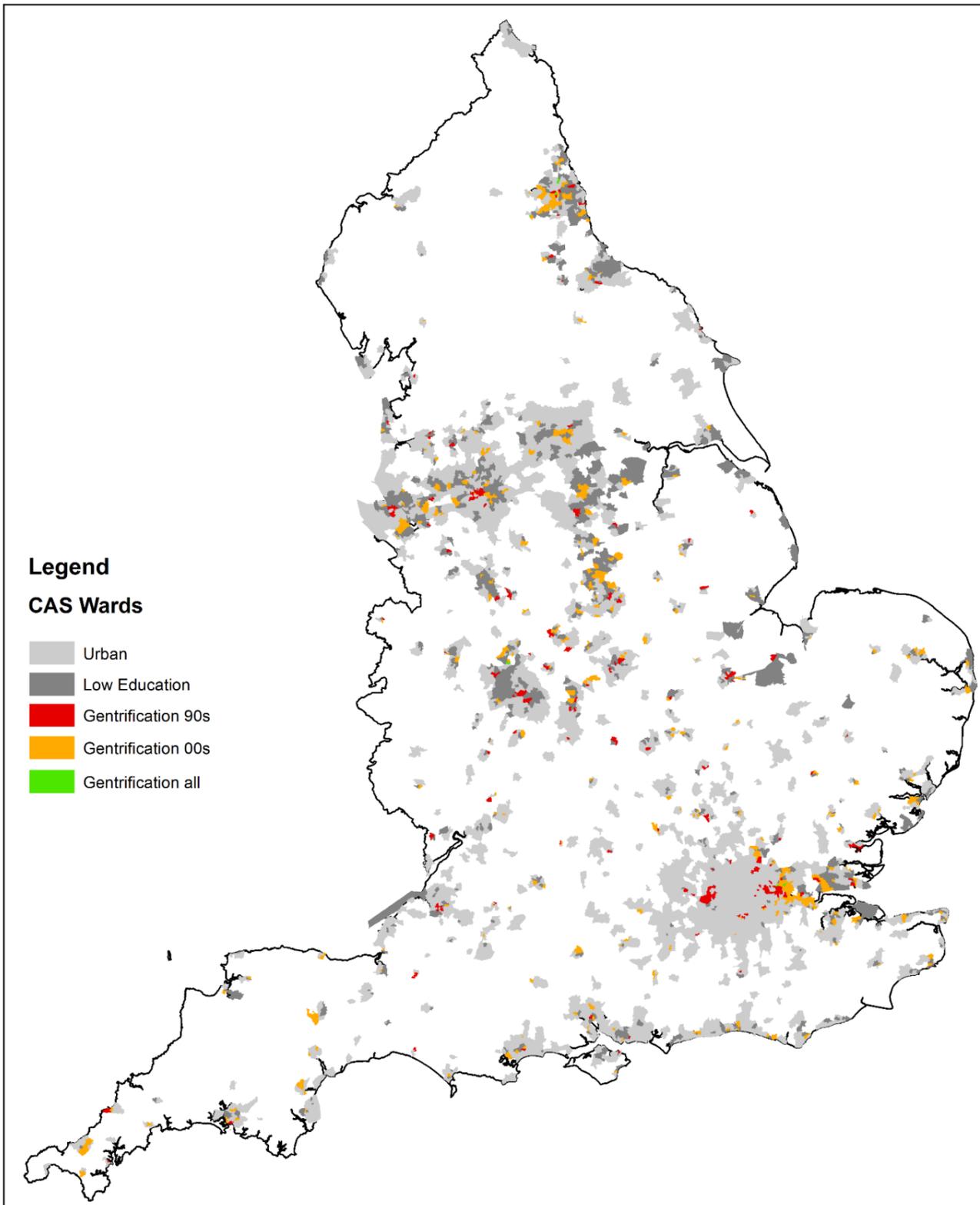
3.2 The households (BHPS)

The BHPS is an annual survey of a representative sample of more than 5,000 British households. Interviews are conducted with heads of households and with all other household members over the age of 16. Heads of household are re-interviewed in subsequent waves. If the heads split from their previous household then all the members of their new households are also interviewed. In this study, each survey entry for a head of household in any wave represents a single observation. By merging together the heads of households across waves it is possible to see if a head of household observed in a particular year lives in a different ward in the next year. This feature will help construct the dependent variable of household exits that will be used to identify displacement.

Previous literature has highlighted the importance that measures of displacement look at forced moves rather than due to normal reasons such as employment changes. A different variable in the BHPS asks individuals whether they lived at the same address last year and if they report “no” then it asks a follow question relating to the reason for the move. The reasons given in the BHPS for moves are wide ranging and often unspecific such as “felt like a change”. Unfortunately, there exists no category for movements due to rising housing costs. Responses that cite “move to larger” or “move to smaller” accommodation do not help too much because it may be that displaced households move from a small property with escalating rents to a larger home somewhere far cheaper. The only category that appeals to displacement are directly is “evicted, or repossessed”. However this represents too few observations to be of much use (80 evictions across all observations). The categories “moved for employment reasons” and “split from partner”, however, cannot plausibly be linked to displacement. Therefore the dependent variable for a head of household-year i is coded as 1 if the head resides in a different ward in the next year and if the move was not for employment reasons or a split from partner. The variable is coded as 0 if the head lives in the same ward or if the exit was for employment reasons or a split from partner. If the head is not observed again in any later waves the variable is coded as missing.

After coding exits I then dropped all observations where exits were unknown because the head of household is not observed again in the sample (6.6% of observations). This means dropping all observations for heads in the last year that they are observed and all observations from the last wave (2008) of the BHPS.

Figure 2: Gentrification map of England (1991-2011)



Notes: Urban is defined as a ward that belongs to a settlement of over 10,000 in population. Low education is a ward that is in the 5th quintile for initial degree share in either period. Gentrification is if the change in degree share in in the 1st quintile for that period.

Since gentrification is an urban phenomenon all observations were dropped where the ward is not categorised as urban (21.7% of the observations). I also dropped all observations not in England. The resulting dataset is 39,170 observations, which is around 53.9% of the original sample of 72,739 observations. I obtained Lower Layer Super Output Area (LSOA) identifiers for household location under a Special Licence Access from the Economic and Social Data Service (ESDS). I aggregated these to CAS Wards, which are described in the previous section, and merged the households data with neighbourhood characteristics from the UK Census, in particular degree share variable described above.

The BHPS also provides a very rich set of household characteristics. Household income is important since this study aims to examine the effect in particular for low income households. I reflat household income to 2011 prices and then calculated the median household income for each Travel To Work Area (TTWA). These TTWAs resemble economic zones in which most people live and work within their boundaries. They are designed such that as few commutes as possible cross their boundaries. Since poverty is a relative measure, these economic zones represent a good benchmark for regional variations in household income. Other control variables used are the age of head of household, the tenure status, whether renters receive housing benefit and whether landlords are private. Renters with private landlords are those that do not live in social housing or let housing from friends, employers or any type of housing association.

Table 6 provides summary statistics of the variables and control variable that will be used in the regression analysis. The table includes mean values or percentage shares for the categorical variables. It also provides exit rates for the categorical variables. These can be compared with the baseline exit rate of 7.3%. Household head types with striking differences from the baseline include Pensioners (at 2.6%), homeowners (at 4.8%) and renters with private landlords (at 28.4%). The lower rates for pensioners, higher rates for renters, and higher still for private rents are consistent with previous literature (e.g. Freeman 2005).

Table 6: Descriptive statistics for variables used in regressions

Variable	Mean	Std. Dev	Min	Max	Exit rate
Change in degree share	0.064	0.041	-0.115	0.308	
Lag degree share	0.146	0.088	0.005	0.655	
Homeowner dummy	0.625	0.484	0	1	0.048
Household income (TTWA-adj.)	0.773	0.426	0	103	
Decade dummy: 90s	0.584	0.493	0	1	0.071
Holds a degree	0.082	0.274	0	1	0.127
Private landlord	0.081	0.274	0	1	0.284
Housing benefit	0.094	0.291	0	1	0.057
Number of children	0.503	0.945	0	8	
People per room	0.516	0.266	0	5	
- Unknown/missing	0.027	0.161	0	1	0.168
Male	0.525	0.499	0	1	0.070
Age of household head	50.9	20.01	0	98	
Head > 65 years age	0.313	0.464	0	1	0.026
Self-employed	0.064	0.245	0	1	0.063
Employed	0.414	0.493	0	1	0.086
Unemployed	0.041	0.199	0	1	0.104
Born outside UK	0.033	0.178	0	1	0.070
Married	0.422	0.494	0	1	0.045
Divorced	0.165	0.371	0	1	0.070
Widowed	0.163	0.370	0	1	0.029
Health score: 1 Excellent - 5 Very Poor	1.98	1.195	1	5	
- Unknown/missing	0.137	0.344	0	1	0.068
Likes neighbourhood	0.865	0.342	0	1	0.066
Years living at address	11.8	13.6	0	86	
- Unknown/missing	0.062	0.241	0	1	0.038
Satisfied with house: 1 -7	3.22	2.86	1	7	
- Unknown/missing	0.396	0.489	0	1	0.069
House needs maintenance	0.170	0.376	0	1	0.094
Lag vacancy rate	0.040	0.024	0	0.331	
Lag population density	3,523	2,609	48	25,013	
Employment potentiality	1.10E+06	1.60E+06	3021	1.20E+07	
Ward size (km ²)	5.45	8.65	0.41	153.7	
Distance (km) to TTWA centroid	9.50	4.93	0.27	26.9	

Notes: The Mean column gives shares for categorical variables and means for non-categorical variables. Categorical variables are also given an exit rate in the final column. Exit rate refers to exit from neighbourhood not for employment reasons. The baseline exit rate is 0.073.

4 Empirical strategy

The strategy outlined here aims to deal with the empirical problems posed by the fact that gentrification may be associated higher exit rates for reasons other than displacement. This is fundamentally a problem caused by sorting. I first highlight the issues, and then implement empirical steps to address them.

4.1 The sorting problem

Households of different types sort into neighbourhoods with different characteristics. As shown in the BHPS data, households with different observed characteristics have different mobility rates. Therefore, some neighbourhood types may have higher 'natural' mobility rates than others. If these neighbourhoods are also gentrifying neighbourhoods then it may appear to be displacement when it is simply higher natural mobility. This can only partly be dealt with by controlling for observable household characteristics because households also differ unobservably. There are two main reasons why neighbourhoods with high natural mobility rates may be identified as gentrifying neighbourhoods.

Firstly, it may be that high mobility neighbourhoods are the same type of neighbourhoods that typically gentrify. For instance, if neighbourhoods with good rail access are (a) more likely to gentrify (as shown by Helms, 2003) and (b) traditionally home to residents with high mobility rates. This could be the case if double-job households have higher mobility rates and are attracted to neighbourhoods with good rail access⁵. Secondly, it may be that high mobility in neighbourhoods leads mechanically to increases in degree share. There is a general increasing trend in degree share over the sample period so neighbourhoods with higher turnover, may experience faster degree share changes where new highly educated generations simply move in to any free housing unit. To sum up these empirical concerns, both are caused by differences in mobility across different types of neighbourhood due to sorting. The first occurs when high mobility neighbourhoods attract gentrification due to the same characteristics. The second occurs when high mobility neighbourhoods mechanically gentrify.

4.2 Approach

The following empirical steps aim to address the problems caused by sorting. Firstly, in addition to household controls, I add neighbourhood controls like population density and employment accessibility. These controls aim to capture neighbourhood characteristics that may be

⁵ Conversely it may be that double-job households have lower mobility rates since they do not typically wish to move once they have found a neighbourhood with good accessibility to both jobs. In this case actual displacement may be concealed by their lower initial mobility rates.

associated with higher mobility rates (and gentrification). However, this does not help with unobserved neighbourhood differences. Therefore, secondly, I implement a fixed effects model that controls for any differences in mobility rates associated with fixed unobservable differences in neighbourhoods. This is helpful to the extent that the neighbourhood factors associated with different mobility rates are fixed over time. The factors that are typically thought to lead to gentrification such as centrality, rail access and housing stock are relatively fixed.

However, time-variant unobserved neighbourhood characteristics remain a problem. To help with this, thirdly, I eliminate from the sample all residents who have been in the neighbourhood for 5 year or less. This helps ensure I do not identify from new residents arriving with different mobility rates in gentrifying periods⁶. It does not help, though, if the old residents were already different in a way correlated with future changes in neighbourhood unobservables. Further, it does not help if neighbourhood changes directly lead to exits. This may be the case if, for example, a factory employing low income workers closes. Fourthly then, I interact the gentrification variable with household income, a renter dummy and the interaction of the renter dummy with household income⁷. The specification ensures that any general differences in mobility rates in gentrifying periods that are not to do with displacement are absorbed by the uninteracted gentrification variable. It also ensures that differences in mobility across income or homeownership (but not related to displacement) are absorbed by the income and renter interactions. Finally, the renter-income interaction captures displacement by estimating how exit rates of renters under gentrification changes with income compared with homeowners. Renters become less vulnerable as their incomes increase, whereas, homeowners do not since they are not susceptible to displacement at any income level. Such an empirical strategy would not have been possible in the U.S. literature that has preceded this, since homeowners in the U.S. may be displaced as a result of home price increases since their tax liabilities increase.

4.2.1 Renter displacement

Following the above steps I estimate this OLS⁸ model for households living in the neighbourhood for more than 5 years:

⁶ It also ensures I am really looking at ‘original residents’ which stays closer to the idea of displacement.

⁷ Interactions are not new to the displacement literature. However, typically only one indication of low status is used, such as low education. The use of both renter and income as separate and combined interactions is novel. So is the use of continuous income rather than a ‘low income’ dummy variable. And is the use of private renters, as defined further down.

⁸ Binary outcome variable is usually estimated using logit or probit models, but an OLS estimation is also feasible. A logit specification is presented in the appendix and the results remain qualitatively similar.

$$\begin{aligned}
E_{iwt} = & \alpha + \beta_{MobRent}(Gent_{wt} \times Renter_i) + \beta_{Disp}(Gent_{wt} \times Renter_i \times Hinc_i) \\
& + \beta_{Mob}(Gent_{wt}) + \beta_{MobInc}(Gent_{wt} \times Hinc_i) + X_i\Psi + W_{wt}\Omega + Y_y + f_w \\
& + \varepsilon_{it}
\end{aligned} \tag{1}$$

where E_{iwt} is the neighbourhood exit indicator for household i living in ward w observed in intercensal period t , $Gent_{wt}$ is a gentrification variable described further down, $Renter_i$ is a dummy variable for renter households, $Hinc_i$ is household income normalised to 1 = Travel to Work Area (TTWA) median, X_i is a vector of household control variables, W_{wt} are ward controls, Y_y is a set of year effects, and f_w are the ward fixed effects. The parameters to be estimated are the constant term α , the gentrification parameters $\beta_{MobRent}$, $\beta_{DispHinc}$, β_{Mob} and β_{MobInc} , the vector of household control parameters Ψ , the ward control parameters Ω and the year and ward effects.

This empirical model implements all four steps discussed so far and should eliminate a large proportion of non-displacement mobility differences associated with gentrification. The fixed effects and ward controls eliminate all but unobservable time-variant differences neighbourhoods. Time-variant neighbourhood unobservables may attract higher mobility residents but these households are dropped from the analysis. Finally, the interaction terms capture remaining differences in natural mobility of original residents that are general (β_{Mob}) or related to income (β_{MobInc}) or homeownership ($\beta_{MobRent}$). The mechanical relationship between mobility and gentrification discussed above will also be captured by these parameters. Therefore, the parameter β_{Disp} should capture just displacement. It tells us how household income changes the relationship between under gentrification and household exits for renters compared with homeowners. If displacement occurs then β_{Disp} is expected to be negative. This tells us that as income goes up the exit rates of renters under gentrification goes down compared with homeowners.

Finally, going back to the $\beta_{MobRent}$ parameter, as well as absorbing the non-displacement differences between renters and homeowners under gentrification, this will include the displacement effect for renter households evaluated for an income of zero. Therefore, to the extent that homeowners act as decent controls for renters, this is expected to positive.

4.2.2 Private renter displacement

The above specification essentially uses homeowners of different incomes as a control for renters of different incomes. This may not be appropriate where e.g. low income homeowners react in significantly differently to changes in neighbourhood characteristics to low income renters. Therefore, I propose an alternative model private renters become the vulnerable group

with social renters as the control. I estimate the following model dropping homeowners from the sample:

$$E_{iwt} = \alpha + \beta_{MobPriv}(Gent_{wt} \times Private_i) + \beta_{Disp}(Gent_{wt} \times Private_i \times Hinc_i) \quad (2) \\ + \beta_{Mob}(Gent_{wt}) + \beta_{MobInc}(Gent_{wt} \times Hinc_i) + X_i\Psi + W_{wt}\Omega + Y_y + f_w \\ + \varepsilon_{it}$$

where $Private_i$ indicates if the renter rents from a private individual or corporation. The omitted category is social renter, where the household live in social housing, rents from a housing association, or rents from family, friends, or employer. Since renters of different types should be more similar to each other than renters and homeowners, this represents a stronger counterfactual strengthening the likelihood that β_{Disp} captures displacement. It also makes it more likely that $\beta_{MobPriv}$ (rather than $\beta_{MobRent}$ above) captures the displacement effect evaluated at an income of zero. However, the drawback is that there is a smaller sample of households and the estimates may therefore be less precise.

4.2.3 Income bands

In a final specification the gentrification effect is estimated across five income bands: 0-0.4, 0.4-0.8, 0.8-1.2, 1.2-1.6 and 1.6-2 times the TTWA median household income. I estimate the following model for both the renter and private renter models⁹:

$$E_{iwt} = \alpha + \sum_b \beta_{b,Dis}(Gent_{wt} \times Renter_i \times Hinc_{b,i}) + \sum_b \beta_{b,Mob}(Gent_{wt} \times Hinc_{b,i}) \quad (3) \\ + X_i\Psi + W_{wt}\Omega + Y_y + f_w + \varepsilon_{it}$$

where $Hinc_{b,i}$ is coded to one if a household i falls into income band b . For this model I drop all households with an income above 2.4 times the TTWA median which leaves a residual income band of 2-2.4 TTWA-medians. This is upper band is close enough to the other bands such that households should be (unobservably) similar. Nevertheless the income level is high enough such that renters should be particularly vulnerable to displacement. Thus the differential effect at this income level should capture purely the difference in mobility level between the two groups associated with gentrification but not due to displacement. The parameters $\beta_{a,Dis}$ in this model are interpreted as the displacement effect at income band b since they are net of the constant difference in mobility rates between renters and homeowners under gentrification. Thus wealthy renters serve as a control for low income renters. This specification is also estimated using the private renter model.

⁹ Only the renter model is indicated in equation (3). The private renter model replaces the renter variable with the private variable and drops all homeowners from the sample.

4.2.4 The gentrification variable

I acknowledge that gentrification occurs at different speeds and is at different stages of development in different neighbourhoods. Therefore, I use the actual change in degree share to capture the pace of gentrification and interaction of change in degree share with initial degree to capture the stage of development¹⁰. The *Gent* variable in the above estimation equations is replaced with two separate variables each with their own parameter to be estimated:

$$\beta Gent = \beta_1 \Delta D_{wt} + \beta_2 (\Delta D_{wt} \times D_{wt-1})$$

where ΔD_{wt} is the change in degree share in ward w over intercensal period ending in t and D_{wt-1} is the initial degree share. The parameter β represents the original parameter for gentrification (interacted or uninteracted versions) which is replaced by two new parameters in each case. The β_1 parameter is interpreted as the impact on exit rates of changes in degree share where the initial degree share is zero. Hence this is the constant term for the gentrification effect by stage of development. Then β_2 gives how this gentrification effect varies with respect to the initial degree share or, put another way, how gentrified the neighbourhood is to begin with. Finally, I also add the un-interacted lagged degree share as a ward control¹¹. This could be interpreted partly as the lagged effect of earlier waves of gentrification but here I simply interpret it as a control.

4.3 Consideration of an IV approach

The empirical strategy presented above attempts to deal with differences in mobility due to the sorting of different households across neighbourhoods of different types. However, it remains a possibility that the groups highlighted as potentially vulnerable to displacement (low income renter, particularly private renters) have exit higher exit rates under gentrification for reasons unrelated to displacement. The only full solution to this problem would be to instrument for gentrification. However, good instruments are notoriously difficult to find in most scenarios. Given that gentrification and displacement are so tightly interlinked it seems implausible that an exogenous instrument may be found. Specifically, most factors that predict gentrification (e.g. rail access) are likely to also determine the mobility rates of original residents. Further, if the neighbourhood were subject to some sort of random amenity shock that lead to

¹⁰ This has the drawback of identifying from negative changes, but since only 2% of the degree share changes are negative, this is not considered a significant issue.

¹¹ The initial share controls for the precise level of education in the neighbourhood rather than a fairly wide band. Initial degree share is likely to be correlated with various unobserved neighbourhood and household characteristics that can also effect exit rates. Simply restricting to the lowest quintile is problematic if, for example, within the low education band, the neighbourhoods that gentrify are typically toward the top end and therefore different types of neighbourhood.

gentrification, there is no guarantee that the same amenity shock does not lead directly to elevated exit rates of original residents (violating the exclusionary restriction). Overall, since both the explanatory variable (gentrification) and the dependent variable (neighbourhood exits) represent location decisions of households, I am unable to think of an instrument that affect one but not the other. Therefore, the empirical approach taken in this paper is to remove as much unobserved heterogeneity as possible through the use of fixed effects and interaction terms that capture treatment intensity. The aim being to demonstrate an association between gentrification and elevated exit rates in a way that is consistent with displacement activity across a variety of alternative specifications. The results are presented in the next section.

5 Results

Table 7 reports the results for the OLS estimation of equation (1) which compares renters with homeowners. This table only reports coefficients of the variables interacted with the change in degree share. The full table of coefficients is reported in the appendix. Column (1) includes just a basic set of control variables¹² and year effects Y_y . Column (2) introduces ward level controls, column (3) household controls and column (4) is the fixed effect specification. The first four rows' coefficients report mobility differences under gentrification in the early stages (i.e. at a zero initial share). The next four rows describe how these mobility differences change with the advancement of gentrification.

Table 7: Renter displacement regression (OLS)

		(1)	(2)	(3)	(4)
Dep. Var.: Household exits					
Change in degree share × Renter	$\beta_{1,MobRent}$	0.371 (0.235)	0.389 (0.236)	0.431* (0.233)	0.666** (0.262)
Change in degree share × Renter × Household income (TTWA-adj.)	$\beta_{1,Dis}$	-0.321 (0.221)	-0.356 (0.223)	-0.415* (0.214)	-0.637** (0.262)
Change in degree share	$\beta_{1,Mob}$	0.076 (0.117)	0.050 (0.118)	0.035 (0.125)	0.390* (0.226)
Change in degree share × Household income (TTWA-adj.)	$\beta_{1,MobInc}$	0.059 (0.074)	0.068 (0.074)	0.098 (0.076)	0.170* (0.097)
Change in degree share × Lag degree share × Renter	$\beta_{2,MobRent}$	-0.774 (1.235)	-0.878 (1.247)	-0.859 (1.249)	-1.979 (1.433)
Change in degree share × Lag degree share × Renter × Household income (TTWA-adj.)	$\beta_{2,Dis}$	1.018 (1.145)	1.245 (1.156)	1.377 (1.106)	2.794** (1.388)
Change in degree share × Lag degree share	$\beta_{2,Mob}$	-0.514 (0.577)	-0.461 (0.581)	-0.381 (0.610)	-1.376 (0.911)
Change in degree share × Lag degree share × Household income (TTWA-adj.)	$\beta_{2,MobInc}$	-0.227 (0.321)	-0.256 (0.324)	-0.395 (0.334)	-0.809 (0.495)
Basic controls (Incl. Year effects)		YES	YES	YES	YES
Ward controls			YES	YES	YES
Household controls				YES	YES
Ward fixed effects					YES
R ²		0.002	0.003	0.023	0.017
AIC		-17738.5	-17756.4	-18290.0	-21201.4
Observations		28,460	28,460	28,460	28,460

Notes: Basic controls are all remaining possible combinations of interaction terms for the reported interacted variables plus year effects. The full table in the appendix reports all coefficients. Standard errors in parentheses clustered on wards in all models.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The second row coefficient $\beta_{1,Dis}$ gives the displacement parameter for the early stages of gentrification (zero initial degree share). The coefficient is negative (but not always significant) across all models and is significant at the 5% level in the strongest, fixed effects, specification. A negative finding indicates the existence of displacement since relationship between

¹² basic controls are included to maintain the hierarchy of interaction terms.

gentrification and neighbourhood exits decreases with income for renters (compared with homeowners). In column (4), an increase in household income by the Travel to Work Area median reduces the effect of a one point increase degree share on probability of exit by 0.637 points. To put this into context, the displacement effect can be computed for a neighbourhood (with a zero initial degree share) that experiences a top quintile increase in degree share of about 0.12. A household with 0.5 compared with 1.5 times the TTWA median would have an increased exit rate of $(0.12 \times 0.637 =) 0.076$ for renters over homeowners. Given the baseline exit rate is around 0.073 this represents a large effect.

The positive and significant coefficient for the interaction with initial degree share ($\beta_{2,Dis} = 2.794$) suggests that the displacement effect disappears as gentrification progresses. In fact it reaches zero at a degree share of 0.14 (approximately the mean in 1991). Together these findings indicate that displacement is significant in the early stages of gentrification but disappears once the neighbourhood becomes significantly gentrified. This could be explained by considering that the households most *unobservably* vulnerable to displacement are displaced early on the gentrification process. But by the time that the ward has a high degree share, those households that remain are probably more capable of resisting displacement in ways not captured by observed income i.e. if they have savings or financial help from family.

The mobility coefficients also allow for interesting interpretations. The coefficient on the change in degree share interacted with renters in the first row ($\beta_{1,MobRent}$) tells us that a one point increase in degree share is associated with a 0.666 point increase in the exit rates evaluated for a renter household with an income of zero (in a neighbourhood with a zero initial degree share). This is consistent with displacement. However, as discussed in the empirical strategy, the coefficient also captured any difference in natural mobility levels between renters and homeowners under gentrification. The other mobility terms, tell us that exit rates for homeowners (the comparison group) are higher under gentrification ($\beta_{1,Mob} = 0.390$) and that higher income increases probability of exit under gentrification ($\beta_{1,MobInc} = 0.170$). The income interaction is small, positive and barely significant suggesting income does not impact too greatly on mobility rates under gentrification in general. This provides reassurance that the strong negative coefficient for the income-renter interaction is due to displacement, not natural mobility differences.

Table 8 presents the results for the private renter model of equation (2). Here, the counterfactual is improved since social renters are likely to share more characteristics with private renters than homeowners do with renters. However, the sample size is significantly reduced and the estimates may be less precise. In this model the displacement parameter

$(\beta_{1,Dis})$ is much larger and significant across all specifications. It remains 5% significant in the fixed effects model. Whilst the variation change across income for private renters is very large ($\beta_{1,Dis} = -4.222$) the change across income in general (i.e. for social renters) is insignificant. This suggests that all the effect observed in the above renter vs. homeowner model comes from private renters that make up only 9% of head of household-years in the sample of 5,990. Furthermore, the intercept mobility differences for private renters ($\beta_{1,MobPriv}$) is positive and significant in all models (although at only 10% level in the fixed effect specification). As discussed in the empirical strategy is stronger evidence for displacement (at zero income) than the equivalent parameter in the renter vs. homeowner model.

The interactions with lagged degree share show again that these effects decrease with the stage of gentrification. The $\beta_{2,Dis}$ parameter shows the displacement effect becomes zero at a degree share of around 0.20, which is in the 2nd quintile across both decades. Therefore, the private renter model highlights a much larger displacement effect which also persists longer through the stages of gentrification.

Table 8: Private renter displacement regression (OLS)

		(1)	(2)	(3)	(4)
Dep. Var.: Household exits					
Change in degree share × Private	$\beta_{1,MobPriv}$	6.155*** (1.787)	6.218*** (1.789)	5.879*** (1.664)	3.791* (1.930)
Change in degree share × Private × Household income (TTWA-adj.)	$\beta_{1,Dis}$	-4.930*** (1.426)	-5.007*** (1.464)	-4.883*** (1.369)	-4.222** (2.103)
Change in degree share	$\beta_{1,Mob}$	0.125 (0.210)	0.107 (0.212)	0.144 (0.207)	0.698 (0.439)
Change in degree share × Household income (TTWA-adj.)	$\beta_{1,MobInc}$	-0.066 (0.235)	-0.075 (0.237)	-0.069 (0.233)	-0.011 (0.256)
Change in degree share × Lag degree share × Private	$\beta_{2,MobPriv}$	-27.391*** (8.260)	-27.921*** (8.318)	-26.981*** (7.818)	-15.633* (9.008)
Change in degree share × Lag degree share × Private × Household income (TTWA-adj.)	$\beta_{2,Dis}$	24.428*** (7.421)	25.002*** (7.621)	25.250*** (7.259)	21.150* (10.968)
Change in degree share × Lag degree share	$\beta_{2,Mob}$	0.120 (1.155)	0.138 (1.164)	0.214 (1.191)	-1.468 (1.732)
Change in degree share × Lag degree share × Household income (TTWA-adj.)	$\beta_{2,MobInc}$	0.032 (1.182)	0.126 (1.199)	-0.156 (1.192)	-0.200 (1.261)
Basic controls		YES	YES	YES	YES
Ward controls			YES	YES	YES
Household controls				YES	YES
Ward fixed effects					YES
R ²		0.019	0.021	0.050	0.038
AIC		-3282.6	-3283.9	-3415.5	-4785.9
Observations		5,990	5,990	5,990	5,990

Notes: Basic controls are all remaining possible combinations of interaction terms for the reported interacted variables plus year effects. Standard errors in parentheses clustered on wards in all models.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The next specification breaks the effect down by income bands. Table 9 and Table 10 show the results of the estimation of equation (3) for renters and private renters, respectively.

Concentrating on strongest results in column (4), the first five rows of Table 9 show evidence of displacement of renters in low income bands in the early stages of gentrification. These coefficients reveal that the difference in exit rates under gentrification between renters and homeowners is far higher in lower income bands than in the wealthy omitted group ($2.0 \leq \text{Income} < 2.4$). The general trend is downwards as income increase, with the only exception being a spike at an income of 1.2-1.6 TTWA medians. This fourth band and the first two bands (0-0.4 and 0.4-0.8 TTWA medians) are statistically significant at least at the 5% level. The next five rows describe how these displacement effects decline with the stage of gentrification. They suggest the effect becomes zero across all income bands at an initial share again of around 0.2, i.e. the 2nd quintile.

Table 9: Renter displacement effect by income bins (OLS)

	(1)	(2)	(3)	(4)
	Dep. Var.: Household exits			
Degree change × Renter				
× (0.0 ≤ Income < 0.4)	1.784** (0.734)	1.751** (0.745)	2.033** (0.790)	2.088*** (0.725)
× (0.4 ≤ Income < 0.8)	1.248* (0.670)	1.238* (0.675)	1.426** (0.713)	1.579** (0.666)
× (0.8 ≤ Income < 1.2)	0.551 (0.712)	0.532 (0.709)	0.877 (0.744)	0.834 (0.691)
× (1.2 ≤ Income < 1.6)	1.869* (0.961)	1.809* (0.973)	2.154** (0.994)	1.750** (0.886)
× (1.6 ≤ Income < 2.0)	0.385 (0.925)	0.329 (0.922)	0.366 (0.918)	0.116 (0.736)
Degree Change × Lag degree × Renter				
× (0.0 ≤ Income < 0.4)	-6.650* (3.818)	-6.872* (3.951)	-8.585** (4.342)	-10.591** (4.116)
× (0.4 ≤ Income < 0.8)	-4.848 (3.515)	-5.150 (3.581)	-6.253 (3.887)	-8.802** (3.715)
× (0.8 ≤ Income < 1.2)	-1.633 (3.679)	-1.972 (3.716)	-3.758 (4.010)	-5.336 (3.793)
× (1.2 ≤ Income < 1.6)	-7.356 (5.015)	-7.424 (5.131)	-9.356* (5.408)	-9.087* (4.790)
× (1.6 ≤ Income < 2.0)	-3.206 (5.568)	-3.300 (5.569)	-4.039 (5.543)	-3.569 (4.212)
Basic controls (Incl. Year effects)	YES	YES	YES	YES
Ward controls		YES	YES	YES
Household controls			YES	YES
Ward fixed effects				YES
R ²	0.004	0.005	0.025	0.020
AIC	-16526.2	-16540.8	-17014.1	-19695.8
Observations	25,759	25,759	25,759	25,759

Notes: Basic controls are all remaining possible combinations of interaction terms for the reported interacted variables plus year effects. Income is household income normalized to 1=TTWA median. Omitted income category is $2.0 \leq \text{Income} < 2.4$. Standard errors in parentheses clustered on wards in all models.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10 gives the result for the comparison between private renters and social renters. Again, for private renters the effect sizes are very much larger. A 1 point increase in degree share is associated with a 21.6 point increase in the probability of exit for household with lowest income

compared with their TTWA median. To put this into perspective, for a ward with an initial degree share of zero, even a very small 5th quintile increase in degree share (0.016) would be associated with an increase in exit probability by 0.342. Private renters already have some of the highest exit rates, with a mean of 0.284, but this would still represent a more than doubling of the exit rate. Since an exit probability of 1 indicates guaranteed exit within the year, it is clear that large increases in degree share, as are typical for gentrification, will be associated with almost guaranteed exit of low income private renters. The first three income bands are positive and significant suggesting displacement occurs up to an income of 1.2 times the TTWA median. Since these coefficients are approximately ten times the size of their Table 9 equivalents and private renters make up 10%, of total renters, this is again suggestive that the effects seen for all renters are essentially just the diluted effects of private renters.

Table 10: Private displacement effect by income bins (OLS)

Dependent Variable:	(1)	(2)	(3)	(4)
Household exits neighbourhood				
Degree change × Private				
× (0.0 ≤ Income < 0.4)	22.076** (10.408)	21.583** (10.302)	19.347* (10.420)	21.576** (9.734)
× (0.4 ≤ Income < 0.8)	15.537 (10.229)	14.977 (10.133)	13.461 (10.305)	17.440* (9.682)
× (0.8 ≤ Income < 1.2)	21.523** (10.333)	21.204** (10.250)	18.934* (10.436)	23.896** (9.878)
× (1.2 ≤ Income < 1.6)	14.212 (10.507)	13.576 (10.430)	11.500 (10.603)	11.047 (10.285)
× (1.6 ≤ Income < 2.0)	7.620 (10.847)	6.934 (10.753)	5.713 (10.775)	10.781 (10.234)
Degree Change × Lag degree × Private				
× (0.0 ≤ Income < 0.4)	-53.158 (46.146)	-52.055 (45.583)	-46.052 (45.945)	-55.534 (42.677)
× (0.4 ≤ Income < 0.8)	-32.079 (45.070)	-30.292 (44.528)	-27.646 (45.128)	-45.146 (42.416)
× (0.8 ≤ Income < 1.2)	-49.631 (44.737)	-49.420 (44.311)	-43.089 (45.041)	-65.634 (42.358)
× (1.2 ≤ Income < 1.6)	-23.880 (49.583)	-21.523 (49.172)	-14.257 (49.910)	10.297 (49.620)
× (1.6 ≤ Income < 2.0)	21.579 (47.921)	24.282 (47.343)	25.237 (47.069)	-3.075 (48.894)
Basic controls (Incl. Year effects)	YES	YES	YES	YES
Ward controls		YES	YES	YES
Household controls			YES	YES
Ward fixed effects				YES
R ²	0.035	0.037	0.064	0.054
AIC	-3197.9	-3198.5	-3320.4	-4710.3
Observations	5,912	5,912	5,912	5,912

Notes: Basic controls are all remaining possible combinations of interaction terms for the reported interacted variables plus year effects. Income is household income normalized to 1=TTWA median. Omitted income category is 2.0 ≤ H. Income < 2.4. Standard errors in parentheses clustered on wards in all models.

* p < 0.10, ** p < 0.05, *** p < 0.01

Finally, in Figure 3 I plot the displacement effects by income band at different initial degree shares. The left column of charts shows the effects for renters over homeowners, and the right

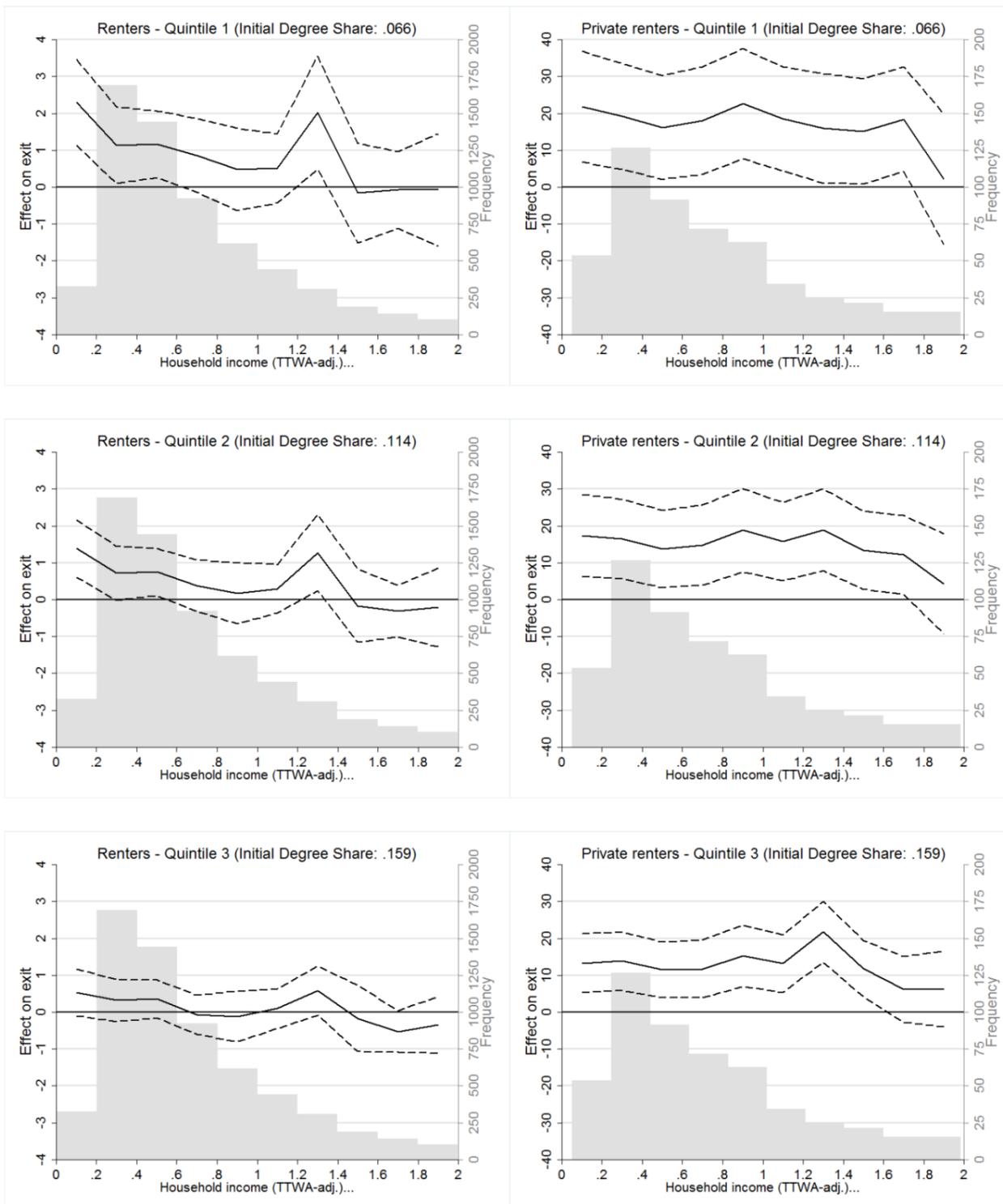
column shows the effects of private renters over social renters. Histograms of the sample distributions across income for renters and private renters are also shown light grey in the chart backgrounds. Since graphical illustration allows for the display of more coefficients, I have used finer income bands of 0.2 TTWA medians in width. The omitted band remains 2-2.4 TTWA median incomes.

The first row of charts shows the effect in the early stages of gentrification (5th quintile of initial degree share). These show displacement is statistically significant up to around 0.6 times the median income for renters, but all the way up to 1.8 for private renters. There is a clear downwards slope across income in both types of comparisons. In the next row (4th quintile) the effects are illustrated for the not-so-early stages of gentrification. Across both models, the size of displacement decrease and the change with respect to income flattens slightly. Once we look at the middle stages of gentrification in the third row (3rd quintile) the effects are insignificant at all incomes for the renter model. The private renter model, however, continue to illustrate displacement activity significant up to 1.6 times the TTWA median income. The fourth row charts illustrate much the same as the third. Only in the fifth row, in the most gentrified of neighbourhoods, does the displacement effect disappear even for private renters (except for the spike at 1.2-1.4 times the TTWA income)¹³. Together the right column of charts suggests very pronounced displacement of private renter households, even where they have an income above the TTWA-median. This makes sense if household up to 1.6 times the median income are not so wealthy as to be invulnerable to rising housing costs. Further, if these households spend approximately the same share of their income on housing as lower income families, or that they are generally households of larger sizes then proportional increases in rents could easily lead to financial difficulties.

To summarise the results of this paper, both the renter and private renter models have indicated significant displacement of low income households in the early stages of gentrification. However, the private renter displacement is a much larger effect that persists longer through the latter stages of stages of gentrification. The effect size indicates that private renters are very quickly displaced from gentrifying neighbourhoods. The results suggest that the effect observed for all renters may be simply the diluted effect for private renters. This makes sense if social housing and housing association rents are not at all linked to market rates.

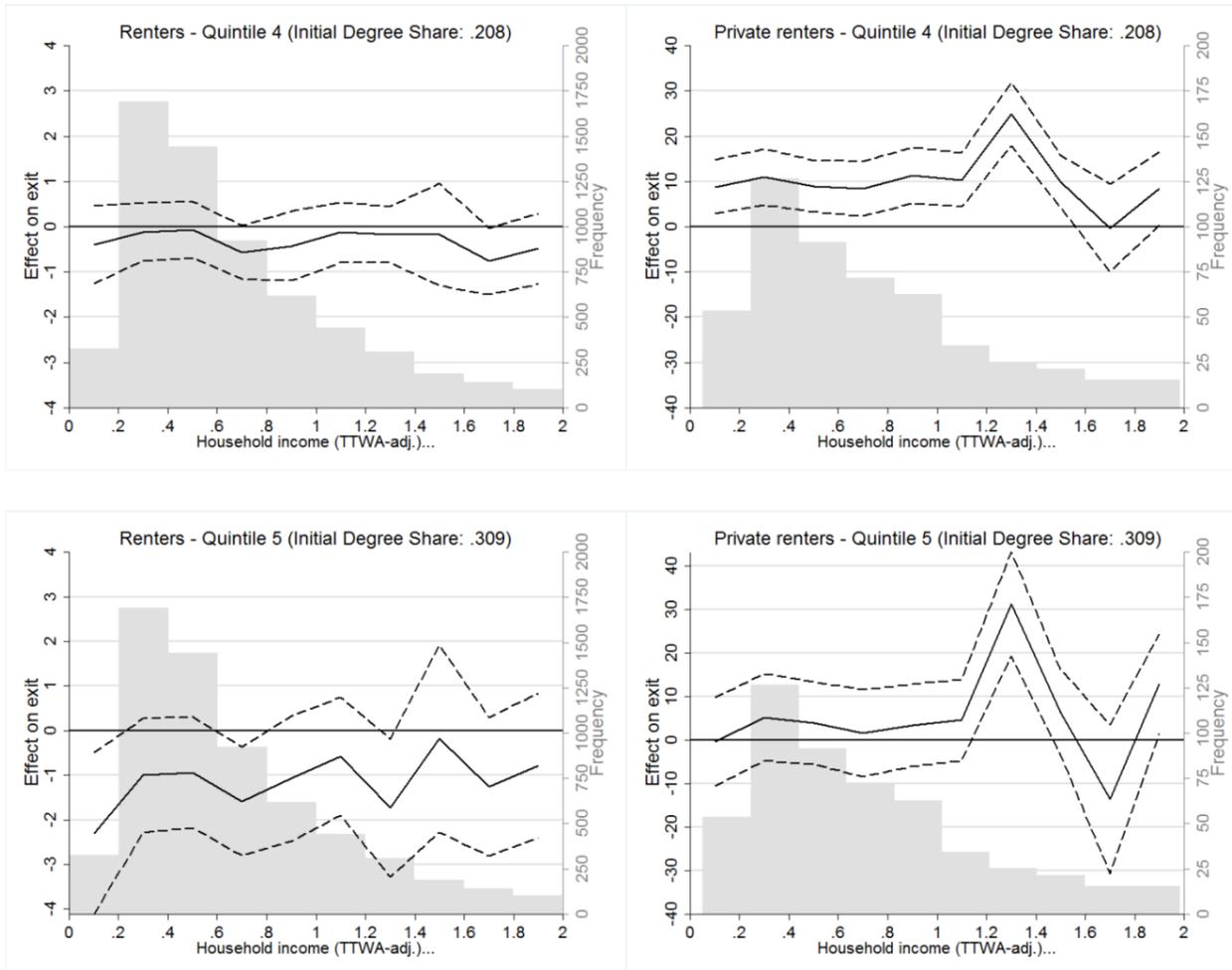
¹³ The sample distribution for the private renter models indicates only around 25 observations or fewer in each income band beyond 1.2 times the TTWA median. Therefore the spike at 1.2-1.4 is most likely due to imprecision in the estimates at high incomes.

Figure 3: Marginal effect of change in degree share on exit



Note: Charts of coefficients based on OLS estimation of equation (3) using ten income bands of 0.2 times TTWA median. Depicted are (a) the marginal effects (solid black lines, left axis) with 5% confidence intervals (dashed lines) and (b) the sample distribution (grey bars, left axis) for renters (left charts) and private renters (right charts).

Figure 3 (continued): Marginal effect of change in degree share on exit



Note: Charts of coefficients based on OLS estimation of equation (3) using ten income bands of 0.2 times TTWA median. Depicted are (a) the marginal effects (solid black lines, left axis) with 5% confidence intervals (dashed lines) and (b) the sample distribution (grey bars, left axis) for renters (left charts) and private renters (right charts).

6 Conclusions and policy implications

This paper has investigated whether gentrification is associated with displacement of pre-existing residents and in particular of low-income (private) renters. It has made methodological advancements over previous literature in terms of controlling for unobservables and investigating interactive effects. In contrast to much of the earlier literature it finds strong evidence for a displacement effect associated with gentrification, measured by change in degree share. Gentrification has been found to be positively associated with higher exit rates of renter households and private renters in particular. A further result is that the effect decreases substantially at more advanced stages of gentrification. This is reassuring because it adds meaning to the definition of gentrification as an inflow of middle class households into a previously working class or poor neighbourhood, setting it apart in consequences from a simple increase in degree share. A potential explanation for finding is that the most vulnerable households have already been displaced from neighbourhoods in the later stages of the gentrification process.

This finding has two important implications for policy. Firstly, policymakers wishing to improve the outcomes for low income households should implement measures to reduce the impact of gentrification on displacement. This may be achieved, for example, by following policies from Germany that prevent the rent eviction of tenants for up to 7 years after newly purchasing a property. The second implication is that more general policies that aim to improve outcomes for the poor may be mistargeted as a result of displacement process. For example, spatially-targeted policies to help the poor miss their target if improvements in local amenities are followed by an in-migration of wealthier households and displacement of pre-existing residents. Furthermore policies aimed at mixing neighbourhoods may be misguided if they too lead to displacement. Policy-makers wishing to improve outcomes for low-income households they may be better off directly targeting incomes and sources of poverty or by combining neighbourhood improvement policies with incentive for low-income renters to become homeowners.

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