The Consumption Choices of "Generation Rent"

Alexandra Elizabeth Brown

Lincoln College

University of Oxford

Submitted in partial fulfilment of the requirements for the degree of the *Masters of Philosophy in Economics*

Trinity 2020

Word count: 17,018

Abstract

This thesis considers two questions: how does the aggregate quantity of consumption by young renters respond to house price shocks, and how has the increase in UK house prices changed how young renters allocate consumption between major expenditure categories. Results from a consumption life-cycle model show a positive relationship between the consumption growth by young renters and house prices. However, I conclude that this reflects a common factor such as income expectations independently determining both variables. I then estimate housing cross-price elasticities of demand for six major expenditure categories using an Quadratic Almost Ideal Demand System (QUAIDS) and UK household expenditure survey data. I identify differences in these elasticity estimates between higher and lower-income young renter households, suggesting that rising house prices and lower homeownership rates is associated with increased financial stress for some households, but increased consumption of luxury goods by others. However, both higher and lower income rental households significantly increased the share of their budgets allocated to housing over the sample period, and experienced large declines in homeownership rates. These results highlight the importance of targeted housing affordability policies that consider these heterogeneities.

Contents

1 Introduction

In the United Kingdom, real house prices have almost quadrupled over the past 40 years, significantly outpacing real income growth (Miles and Monro, 2019). This has reduced the affordability of housing, particularly for first home buyers. More recently, weak wage growth following the Great Recession, and tighter restrictions on mortgage availability have further weighed on housing affordability (Joyce, Mitchell and Keiller, 2017). As a result, there has been a broad-based decline in the homeownership rate of young people, concentrated among middle-income cohorts. The share of young people aged 25–34 with middle-quintile incomes who are owner occupiers fell from 65 per cent in 1995–96 to 27 per cent twenty years later (Muellbauer, 2018). Similar declines have occurred in other advanced economies (OECD, 2019). Young people who in prior generations would have transitioned to being owner-occupiers are remaining in the private rental sector as 'Generation Rent'. While this decline in youth homeownership has been well documented, its impact on the consumption, saving, labour supply and regional migration choices of young people has been little explored in the literature. Therefore, this thesis investigates two questions:

1. How does the aggregate quantity of (non-housing) consumption by young renters respond to house price shocks?

2. How has the increase in UK house prices changed how young renters allocate consumption between major expenditure categories?

The relationship between house prices and consumption by young renters is theoretically ambiguous. Some renters who aspire to become owner-occupiers may respond to a positive house price shock by decreasing their consumption to help save for the bigger down-payment now required, while others may delay or give up their homeownership ambitions, and so increase their consumption. Results from previous investigations of this relationship in the empirical literature have also been mixed. In this literature, the consumption response by young renters to house price shocks has mostly been addressed as part of an investigation into what causes the correlation of consumption and house prices. The cause of this correlation remains contested, therefore so does the response of young renters to house price shocks. To answer my first research question, I adopt the methodology of one of these empirical papers

investigating the consumption house price co-movement (Attanasio et al., 2009), and I estimate a life-cycle model using UK household expenditure survey data. I find that the non-housing consumption elasticity of house price growth is larger for younger households than older households, and conclude that common factors such as income expectations drive the co-movement. Changes in the level or magnitude of decline in youth homeownership appear to have little impact on my estimates, although there is some evidence of asymmetries, with stronger consumption responses during house price upswings. Therefore, young renters in my sample on average increased their non-housing consumption when house prices rose, but I conclude this is mostly not due to a causal relationship between consumption and house prices.

My second question investigates the housing cross-price elasticity of demand for different goods and services, and how house price growth has affected how young renters allocate total expenditure between different consumption categories. Sustained house price growth is likely to significantly affect the allocation of expenditure between housing and non-housing consumption. In the UK, the decline in youth homeownership has occurred alongside a large increase in the budget share young renters allocate to housing. In the media, 'Generation Rent' is popularly depicted as being forced to spend an increasing amount of their income on rent due to rising rental costs, stagnating wages and a shortage of social housing (Joyce, Mitchell and Keiller, 2017). However, there has also been a significant fall in the homeownership rate of high-income young households, some of whom presumably could afford a mortgage but have a preference to remain in rental housing. The increasing housing budget share of this group may reflect their preference to increase the quality of their rental housing, or live in an expensive area with better amenities or job opportunities instead of saving up for a housing deposit. It is unclear to what degree the increase in the housing budget share of young renters reflects preference shifts, possibly linked to the increasing difficulty to transition to homeownership, and financial stress as households cut back on other consumption to make the rent. Determining how house price shocks affect demand for necessities such as food and fuel, and non-necessities such as leisure goods and services, and identifying differences in the budget choices of young renters and homeowners helps detangle these preference shifts from financial pressures.

To answer my second research question, I estimate a Quadratic Almost Ideal De-

mand System (QUAIDS), which is a variant of the Almost Ideal Demand System (Deaton and Muellbauer, 1980*a*) that includes an additional quadratic expenditure term (Banks, Blundell and Lewbel, 1997). I estimate a six equation demand system for food, housing, fuel & light, leisure, other goods, and transport & other services using household expenditure data from the UK's Living Costs and Food Survey and its predecessor surveys over the period of 1987–2017. I use the coefficients from the QUAIDS estimation to calculate expenditure and compensated cross-price elasticities for every young household in my sample. Of particular interest are the housing cross-price elasticities of demand, which indicate how household demand for different types of goods and services respond to house price shocks. I identify significant differences in how young renter and homeowner demand for housing, leisure, and transport & other services has responded to house price shocks between 1987–2017. There has been a decline in the compensated own-price housing elasticity for young renters, suggesting that although housing budget shares have increased, young renters are decreasing their housing consumption by a greater amount in response to positive house price shocks. Over this period, the housing compensated cross-price elasticity of demand for leisure, and transport & other services both increased for young renters but not homeowners. I find that young renter households have become less willing to reduce their consumption of leisure goods and services in response to house price increases. Furthermore, households in the top expenditure quintile have increased their leisure services budget share by seven percentage points, suggesting that the decline in homeownership by this group is at least partially a preference. The increase in the housing compensated cross-price elasticity of demand for transport & other services is driven by middle-expenditure households. A plausible explanation is that high-income renters are increasingly living in inner-city areas with good public transport, while lower-income renters are seeking more affordable rents further away from their job or urban centers, increasing their transport costs.

The final part of my thesis aggregates these consumption responses to price changes into an overall measure of welfare changes. I calculate the compensating variation of all price changes experienced by young households in my sample, which is defined as the amount of additional money a household would need to return to their original utility following these price changes. I find that while housing has become much more expensive over my sample period, the price of most other goods and services

declined relative to the disposable income growth of young households, and so young households in 2017 are better off than those in 1987. However, the purchasing power of young households has stagnated following the Great Recession due to weak income growth relative to price growth, made worse by households allocating an increasing share of their budget towards relatively high-price-inflation items like housing and services.

This thesis makes multiple contributions to the literature. To my knowledge, this is the first paper that considers the impact of house price shocks on consumption data disaggregated into major expenditure categories. In addition, this thesis contributes to the ongoing debate on the drivers of the co-movement of UK house prices and consumption. Finally, this thesis can contribute to the debate on how to formulate better housing affordability policies. Since the decline in homeownership reflects a combination of preferences and genuine affordability constraints, it is important that government housing affordability schemes are targeted to the renters for whom the welfare benefit is large. My focus on the heterogeneity of household responses to the decline in housing affordability can be used to help identify who best to target. I focus on the UK rather than US as the affordability issues in the UK housing market are more comparable to other advanced economies such as Canada and Australia, and therefore this thesis has wider policy applicability[1].

The rest of the thesis proceeds as follows. I begin with summarising the relevant literature. I then introduce my dataset, and identify the major trends in house prices, tenure and consumption of young renters. The next chapters address the two key research questions of this thesis by estimating a life-cycle model and then a QUAIDS model with associated elasticities. I conclude with estimating compensating variation to summarise the welfare consequences of price increases, and a final conclusion.

[1]The US has a much less integrated national housing market, and the acute housing affordability issues in some US cities have locked out a far larger share of the population than young middle-income 'Generation Rent' households.

2 Literature Review

This section summarises what has been learned about the impact of housing price shocks on consumption behaviour and housing tenure in the literature, focusing on young renters.

My first research question on the aggregate (non-housing) consumption response of young renters to house price shocks is considered in the consumption life-cycle literature, and in the literature that investigates the co-movement of house prices and consumption. However, different papers disagree on what causes the correlation between house prices and consumption, and therefore disagree on how young renters are likely to respond to house price shocks, while the consumption response by renters to house price shocks is typically theoretically ambiguous in life-cycle models. My second research question on the intra-temporal substitution between housing and non-housing consumption has received much less attention in the literature, therefore I describe demand system estimation as an approach to investigate this question. I conclude this literature review with briefly summarising various economic margins of adjustment other than modifying consumption that are available to young renters facing house price shocks.

2.1 Life-cycle consumption models

Since housing demand varies significantly over the life-cycle, there is a rich literature in constructing life-cycle models that explain an individuals consumption and tenure choices as a function of their age and lifetime resources (Artle and Varaiya, 1978). These models show that house price shocks have consumption and welfare consequences that differ significantly by age because households cannot fully insure against house price shocks. Credit constraints and transaction costs are a source of additional frictions, particularly for young households whose low levels of current income may prevent them from purchasing a house that optimizes lifetime consumption in spite of a steep expected income profile (Li and Yao, 2007).

These models typically make the following stylized predictions on the relationship between house price shocks, consumption and tenure choice by age (Attanasio et al. (2012) and Li and Yao (2007) are recent examples). An exogenous positive house price shock increases consumption by older households due to wealth effects and a shorter

life-horizon to consume these gains, and substitution effects from an increased propensity to sell their house and downsize. However, for younger households, a positive house price shock decreases consumption by both renters and homeowners. Renters are aversely affected by the co-movement of rent with house prices, and those planning to buy a house need to increase their saving to afford the larger down-payment now required. However, the non-housing consumption response of young renters to house-price shocks is theoretically ambiguous, as some will respond by giving up their homeownership ambitions. This 'discouragement effect' should increase consumption (Engelhardt, 1994). While an increase in house prices should, *ceteris paribus*, decrease the homeownership rate, this may be offset by the ability of aspirational homeowners to adjust their housing demand at the intensive margin. Attanasio et al. (2012) show that an increase in house prices may increase the homeownership rate as young renters substitute from saving to purchase a house to saving to purchase a flat. Flats can be purchased with fewer years of savings, and renters are incentivized to transition more quickly into homeownership to avoid paying higher rents.

This theoretic ambiguity in how consumption by young renters responds to house price shocks is reflected in the mixed results from the empirical literature that observes how house prices affect the use of savings products for a housing down-payment. Yoshikawa and Ohtaka (1989) examine the relationship between land prices and participation in a 'housing purchase plan' savings product in Japan. They observe heterogeneity among different households; while some households drop out of using the savings product when prices increase, those who continue to save using the product slightly increase their rate of saving. The first effect dominates the second. Engelhardt (1994) adopts a similar approach with data on membership in a Canadian tax-deferred savings programme for prospective first home buyers. He finds that high local house prices substantially reduce the probability of saving for a house deposit, although unlike Yoshikawa and Ohtaka (1989), those who continue to save do so more slowly. These results contradict Sheiner (1995), who finds that the effect of higher house prices on saving is positive (and quite large) in the US in 1984 because of the need to accumulate a larger down payment, which more than offsets any small decline in the number of households continuing to save. Sheiner suggests that the difference between her results and Yoshikawa and Ohtaka (1989) and Engelhardt (1994) may be due to cross-country differences in the attractiveness and affordability of housing. In

Japan, a housing deposit was around 50 per cent of the house purchase price at this time, which was much higher than deposit requirements in the US or Canada. These contradictions highlight the importance of approaches that consider heterogeneity of renter responses to house price shocks, which cannot be considered in simple representative agent life-cycle models.

2.2 Housing prices and consumption co-movement

Life-cycle models typically treat house price shocks as exogenous. However, house prices and consumption growth are highly correlated. The causes of this correlation remains contested. The three main causes proposed; the wealth effects channel, the collateral channel, and common (omitted) factors, imply different consumption responses by young renters to house price shocks. The wealth effect channel is the consumption response to an unexpected change in housing wealth. Homeowners who are 'long in housing', such as older homeowners who have a shorter time-horizon to enjoy their capital gains, and homeowners planning to downsize, will respond to a positive house price shock by increasing their consumption. The inverse holds for homeowners who plan to trade-up, and renters who now need to save for a larger down-payment (Berger et al., 2017). The common factor channel captures other omitted variables that independently determine consumption and house prices, so that house price growth does not have a direct impact on consumption. Expected future income or productivity growth is the most likely common factor suggested in the literature. If the correlation is driven by expected future income growth, then a positive house price shock should have a larger (and positive) effect on young households, both homeowners and renters, who consumption smooth by increasing their consumption the most now (Attanasio et al., 2009). Finally, several papers have found strong evidence for a collateral channel, where an increase in housing wealth from higher house prices facilitates borrowing by credit-constrained homeowners (Mian, Rao and Sufi (2013), Aruoba, Elul and Kalemli-Ozcan (2019) are recent examples). A distinct but closely related channel is the 'borrowing-to-invest' channel (Crossley, Levell and Low, 2020) where households borrow for the purpose of residential investment spending instead of consumption, therefore household leverage is a portfolio choice. The collateral and borrowing-to-invest channels should not directly affect the consumption behaviour of

renters.

Once again, there is an ambiguity in the likely consumption response of young renters to house price shocks because the relative strength of these three channels in driving the consumption and house price co-movement is contested, and the different channels imply different consumption responses. Notably, Campbell and Cocco (2007) and Attanasio et al. (2009), use the same UK household-level expenditure data but come to opposite conclusions on this question. Campbell and Cocco (2007) regress changes in a cohort's consumption on changes in house prices and various controls. They advocate for the wealth effects channel because they find a large positive effect of house prices on the consumption of older homeowners and almost no effect for younger renters. Attanasio et al. (2009) regress the level of consumption on age, various controls, and house price growth interacted with age groups dummies. They find that consumption by young households is more responsive to house price changes than older households, despite their lower homeownership rate. This result is consistent with a common factor channel but inconsistent with a wealth effects channel. Additional support for Attanasio et al. (2009)'s results is provided by studies that attempt to control for these common factors. Aladangady (2017) finds that the positive relationship between US house price growth and consumption growth disappears when he uses variation in local zoning regulations as an instrumental variable for house prices. Finally, a replication exercise that attempted to reconcile the contradictory Campbell and Cocco (2007) and Attanasio et al. (2009) results concluded that the different results reflected the assumptions underpinning the different modelling approaches used (Cristini and Sevilla, 2014). Cristini and Sevilla (2014) suggest that Campbell and Cocco (2007)'s Euler equation estimation better captured the year-to-year changes in consumption growth within five-year synthetic cohorts, while Attanasio et al. (2009) better captured life-cycle variation across cohorts, and is therefore more appropriate for longer-term trend analysis. On balance, there appears to be stronger evidence for common factors driving the consumption house price co-movement in the UK in recent decades, rather than wealth effects.

2.3 Housing and non-housing consumption decomposition

While identifying the causes of the co-movement between aggregate consumption and housing has been a popular topic in the literature, there has been much less attention paid to how house price growth affects the allocation of household budgets between different expenditure categories. House price growth is likely to significantly affect the share of a household's budgets allocated to housing and non-housing consumption. The life-cycle literature typically ignores this allocation decision by assuming additive separability between housing and non-housing consumption (Khorunzhina, 2020). A recent exception is Li et al. (2016), who estimate a life-cycle model that jointly identifies intra-temporal and inter-temporal preferences over consumption and housing. They show that the strength of the intra-temporal elasticity of substitution between housing and non-housing consumption determines whether renter households respond to a permanent house price increase by transitioning to homeownership or increasing their non-housing consumption. When the intra-temporal elasticity of substitution is low, a large and persistent house price appreciation coupled with an increase in income leads to a significant increase in homeownership rates, alongside an increase in non-housing consumption. However, when intra-temporal elasticity of substitution is high, an increase in house price growth will encourage renters to substitute to non-housing consumption, and homeownership rates respond very little. Due to the lack of research on this topic, there is very little empirical consensus on the magnitude of this intra-temporal elasticity of substitution coefficient and how it has changed over time or how it differs between different types of households. Responses may also be non-linear by size of house-price shock, as components of non-housing consumption such as food and leisure is easier to adjust than consumption 'commitments' such as housing (Chetty and Szeidl, 2016). Khorunzhina (2020) finds some evidence of younger households exhibiting stronger non-separability between non-durable consumption and housing, but emphasised that large gaps in the literature remain, and in early 2020, called for more research in this area. This thesis contributes to this literature gap by considering both the total level of young renters' consumption response to house price shocks, and its allocation between expenditure categories.

2.4 Demand system estimation

Demand system estimation is a popular method of investigating the relationship between price changes and the allocation of a budget between differentiated products. If we assume that consumers have preferences over products (as opposed to characteristics of those products), then the demand for those products in terms of budget shares can be jointly estimated as a function of prices and total expenditure (or income). For this approach to be tractable, products need to be aggregated into a small number of groups, with a seperability assumption so that preferences over different products within one group is independent of preferences over different products within another group. Then multi-stage budgeting can be assumed, so that households first allocate total expenditure between the small number of highly aggregated groups, and then allocate within each sub-group.

The most popular form of demand system is the Almost Ideal Demand System (Deaton and Muellbauer, 1980*a*), which has been extended and modified in various ways. Almost Ideal Demand System (AIDS) estimation is frequently used in the literature to investigate the impact of price changes on consumer demand of different goods, and therefore the welfare consequences of price changes. Popular applications including modelling the welfare impact of tax reforms (West and Williams, 2007) and anti-poverty initiatives in developing countries (Attanasio and Lechene, 2014). It has also been used to model demand for housing attributes. Parsons (1986) estimates an AIDS model for four attributes of housing: size, features, quality and neighbourhood. I broadly follow the methodology of these papers. However, to my knowledge, I am the first to estimate a demand system to investigate the impact of high house price growth and the associated decline in homeownership on the consumption choices of young people. I describe the technical details of AIDS model estimation in a subsequent thesis chapter.

2.5 Alternate margins of adjustment

In addition to adjusting non-housing consumption or modifying tenure choices, there are other economic margins of adjustment available to young people to respond to house price shocks. I do not consider these in my thesis, but I list them here for completeness. Young people can decrease their consumption of rental housing

by increasing their household size, or returning to their parental home. There has been little empirical research on young people responding to house prices in this way, although Rios-Rull, Kaplan and Dyrda (2016) find evidence of a counter-cyclical relationship between household size and economic conditions (including house price growth), mostly driven by young people returning to or delaying departure from the parental home in periods of weak economic conditions. Young people may also increase their labour supply so that they are a better able to afford a larger down-payment. However, Disney and Gathergood (2018) does not find any evidence of this behaviour in UK micro-data. An alternative way for young people to afford a down-payment in the face of rising house prices is to seek parental support, and there is some evidence that this is increasingly common (Udagawa and Sanderson, 2017).

Finally, renters can move to regions with cheaper housing. However, empirical evidence suggests that the opposite is occurring. Higher house prices are reducing the propensity of young people to move for work, resulting in less efficient labour market matching as the potential wage increases from relocating is increasingly offset by the increased cost of living and rents in high-productivity regions of the UK (Head and Lloyd-Ellis, 2012). As a result, the propensity of young private renters aged 25–34 to move home and job has sharply fallen by two-thirds between 1997 and 2018 in the UK (Judge, 2019).

Having summarised the available evidence in the literature on how the consumption of renters responds to house price shocks, I now describe the household-level expenditure dataset I compile to answer the research questions of this thesis.

3 Data

For my analysis, I compiled two cross-sectional datasets of household expenditure in the United Kingdom, using the Living Costs and Food Survey (LCFS) which began in 2001, and its predecessor surveys, the Family Expenditure Survey (FES) and National Food Survey (NFS).

My first dataset contains aggregate non-durable expenditure data on 251,260 UK households who completed detailed surveys on weekly expenditure, income and the following household characteristics: age, occupation, region, education, number of adults in household, number of children in household aged under 2, aged 2–5 and aged 5–18. A table of summary statistics for these data is provided in *Appendix 9.1.* I deflated the expenditure data by the UK national retail price index excluding mortgage interest payments (RPIX). Although Family Expenditure Survey data is available from 1957, my dataset covers the period of 1978–2018. This starting year was chosen to exclude the period that preceded the mortgage market reforms of the early 1970s, as well as the years immediately following the oil crisis of 1973–4. I merge this dataset with regional Nationwide House Price Index data. This is a non-seasonally-adjusted, quarterly, hedonic, mix-adjusted, nominal house price dataset. These regional house price series are also deflated using the RPIX.

My second dataset disaggregates aggregate expenditure into 14 consumption categories. While the expenditure data I use in my first dataset is available disaggregated, data from different survey years are not directly comparable due to changes in expenditure classifications over time. The LCFS expenditure data are classified into consumption categories based on COICOP guidelines; a standardised UN classification that classifies household consumption into 12 divisions according to purpose. Data prior to 2001 from the FES are divided into 14 main expenditure categories. The 14 FES categories cannot be directly mapped to the 12 LCFS categories; mapping can only be done at a highly-disaggregated sub-category level. To ensure consistency between pre and post-2001 data, I use an expenditure dataset produced by the *Institute for Fiscal Studies* (IFS) (Oldfield et al., 2019). This dataset is derived from FES and LCFS data, but the LCFS data have been adjusted to make them consistent with the FES consumption categories. To deflate these expenditure time series, I use UK retail price indices, which are available from mid-1987 for each FES categories. The IFS

dataset also includes household demographic information such as age of household head, region, number of adults, and number of children. These data are summarised in *Table 1*.

Table 1: Nominal Budget Shares & Household Variables by Age Group
1987-2018

	Percentage Share of Budget			
FES Category	Young	Middle-age	Old	All
Food	12.7	14.2	19.0	15.5
Catering	5.5	5.0	3.7	4.7
Alcoholic drinks	3.9	3.9	3.4	3.8
Tobacco	2.3	2.0	1.7	2.0
Housing	22.6	18.4	16.2	18.5
Fuel, light & power	5.1	5.1	7.7	5.9
Household goods	7.3	7.5	7.9	7.6
Household services	5.5	5.2	6.1	5.5
Clothing & footwear	5.7	5.4	4.2	5.1
Personal goods & services	3.6	3.7	4.5	3.9
Motoring	11.8	13.2	9.9	11.8
Fares & other travel	2.6	2.4	1.7	2.2
Leisure Goods	4.2	4.2	4.3	4.3
Leisure Services	7.1	9.8	9.6	9.3
Other variables				
Age	28.6	47.0	71.3	51.5
Region:				
- North East	5.4	5.2	5.3	5.3
- Yorkshire & the Humber	9.6	9.1	9.1	9.2
- North West & Merseyside	11.5	11.1	11.2	11.2
- East Midlands	7.8	7.8	7.6	7.7
- West Midlands	8.9	9.2	9.2	9.1
- Eastern	6.0	7.0	7.4	7.0
- London	12.0	10.0	8.1	9.8
- South East	16.4	17.3	17.1	17.0
- South West	8.4	9.2	10.4	9.5
- Wales	4.7	5.2	5.4	5.1
- Scotland	9.3	9.1	9.2	9.1
Number of adults	1.8	2.0	1.7	1.9
Number of kids	0.9	0.8	0.0	0.6
N	33,100	82,365	55,984	171,499

*Young households <35 household head, middle-age 35-59, old >60 years old; age data censored so that all individuals aged over 80 are recorded as aged 80; excludes Northern Ireland

4 Summary Statistics

In this chapter I use the two datasets I compiled to illustrate the main trends in house prices, tenure and consumption in the UK over the past forty years, focusing on young renters and how their consumption and tenure choices differ from young homeowners and older age groups.

The main observations are as follows. The large increase in real house prices has been broad-based by UK region, and has occurred alongside a significant decline in the homeownership rates of young households. While middle-income young households experienced the largest decline in homeownership, significant declines also occurred among young higher-income households, despite them presumably facing fewer financial constraints to transition into homeownership. Cohorts born in the 1970–1990s exhibit lower homeownership rates than older cohorts, and this gap does not appear to be closing as these cohorts enter middle-age.

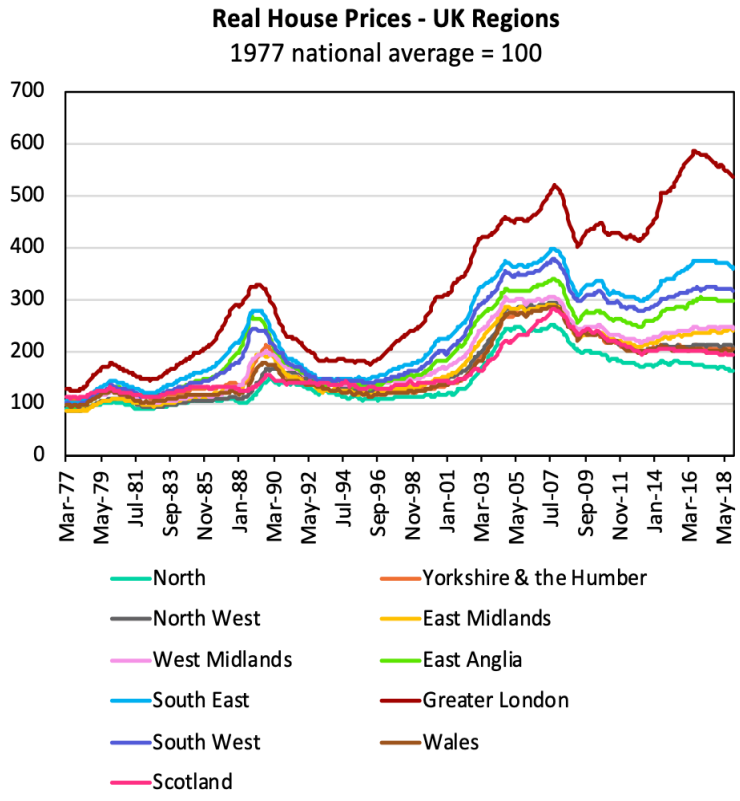
Non-housing consumption for young households was higher than predicted by a simple life-cycle model of consumption by age until the mid-2000s, when it started to decline sharply relative to its predicted level. This decline in non-housing consumption occurred alongside large increases in the housing consumption budget share of young renters from around 15 to 30 per cent of total budget. There is also evidence of a weaker-than-predicted non-housing consumption over this period by older households born in the 1960s and 1970s, suggesting that other factors have been weighing on consumption as well as housing costs.

In the remainder of this chapter I discuss these observations in more detail.

4.1 House prices

Over the sample period, there was a three-fold increase in real house prices. London is an outlier; however, the increase was broad-based by region, particularly during 2000–2006. Following the Great Recession, real house prices outside of London broadly stabilised, although the dispersion in average prices between regions increased. Real housing rents also increased over this period, at a slower pace than house prices but still more rapidly than the real income growth of young adults (Joyce, Mitchell and Keiller, 2017).

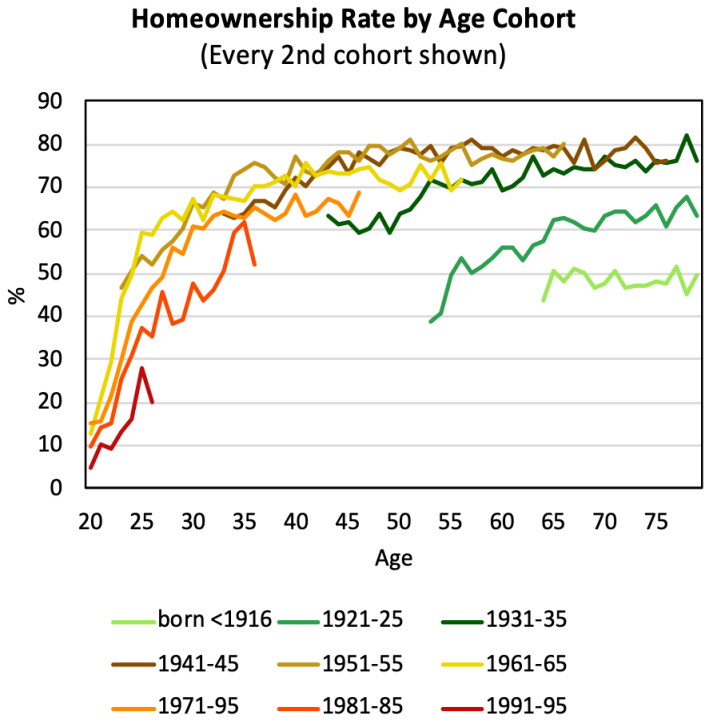
Figure 1



4.2 Tenure

There has been a steady decline in the homeownership rate of young people in the second half of my sample (1998–2017). The decline is largest for middle-income young households, although the homeownership rate for households in the top disposable income quintile, who presumably would have the least financial difficulty transitioning to homeownership, declined by almost 20 per cent. Households with disposable income in the bottom 20 per cent of young households have consistently low homeownership rates, likely reflecting a combination of social housing and student housing. The decline homeownership is broad-based by region, and is not limited to regions with the most expensive houses or fastest house price growth (Cribb and Simpson, 2018)

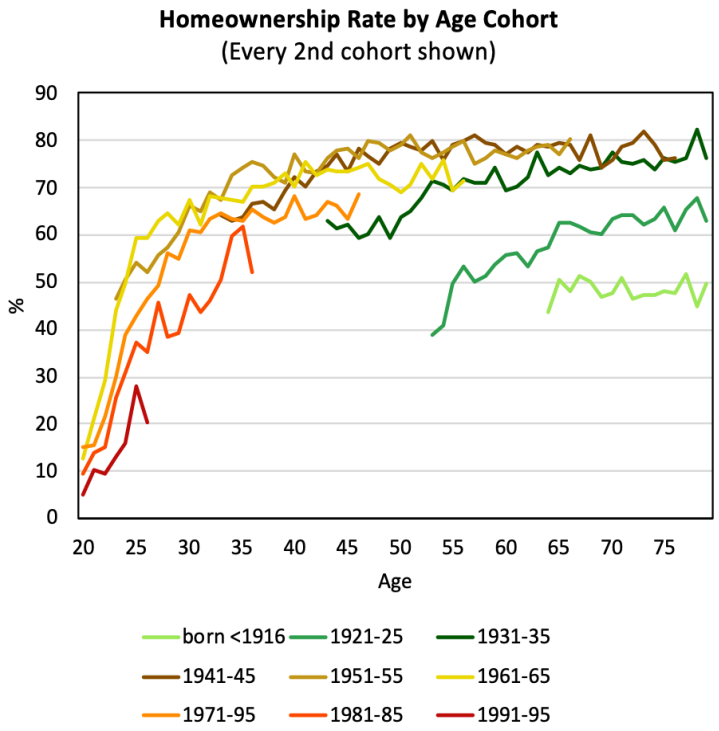
Figure 2



The decline in homeownership likely reflects a combination of shorter-term cyclical factors and longer-term structural trends. A life-cycle approach, where I track the homeownership rate of birth cohorts over time, helps disentangle these factors. A decline in a cohort's homeownership rate caused by shorter-term factors should reverse a few years later as the cohort ages, while a decline caused by longer-term trends will not.

The literature suggests that some of the decline in UK youth homeownership has been temporary, and young cohorts with low homeownership rates often catch up when they age into middle-age. Using a 1969–2007 dataset of UK homeownership, Bottazzi, Crossley and Wakefield (2012) find that cohorts with relatively low homeownership rates at age 30 tend to close around 80 per cent of the gap by the age of 40. However, they also find that this propensity to catch up has weakened over time. My dataset, which includes an additional decade of data, shows a sharp decline in the homeownership rate for several of the younger cohorts that does not appear to be reversing by the age of 40.

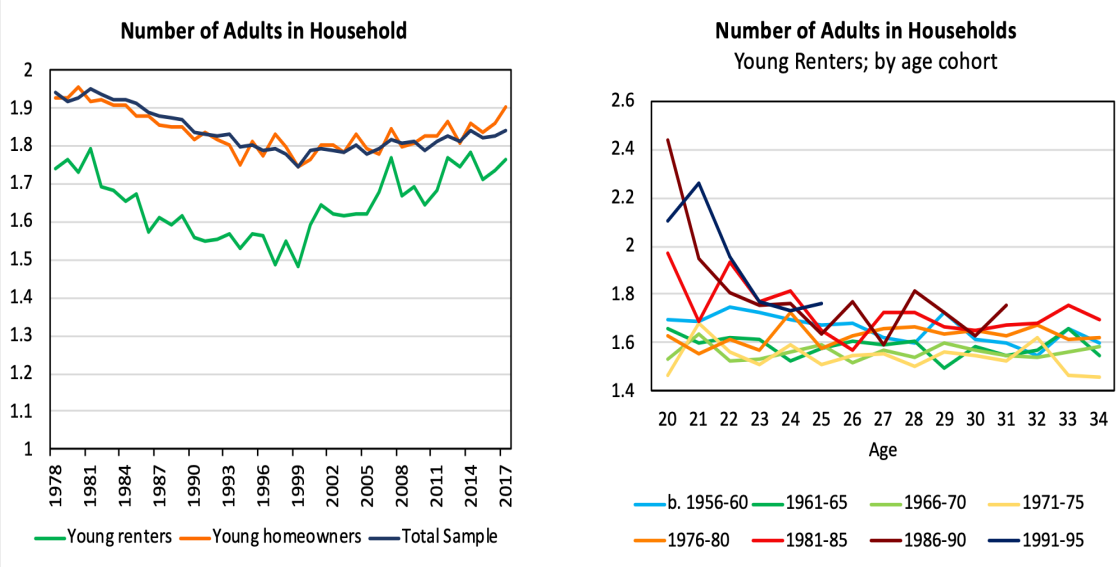
Figure 3



The decline in youth homeownership has occurred alongside an increase in the average number of adults in young households. Graphing the average number of adults in households by age cohort illustrates that cohorts born in the 1980s and 1990s have consistently higher numbers of adults in their households relative to earlier cohorts. This is due to a sharp decline in the share of single-adult rental household relative to two-adult rental households. Two-adult rental households are the group who would most likely have transitioned to homeownership in previous decades, so this increase may reflect the decline in homeownership. However, it could also reflect young renters merging households to reduce rent.

The increase in the average number of adults in rental households also suggests that many more rental households are double-income. The impact of this trend on the consumption choices of young renters is unclear. A double income may enable households to devote more of their income to higher-quality housing or non-essential consumption. Alternatively, it could reflect the increasing financial pressure faced by young renters, who have responded by increasing their household size.

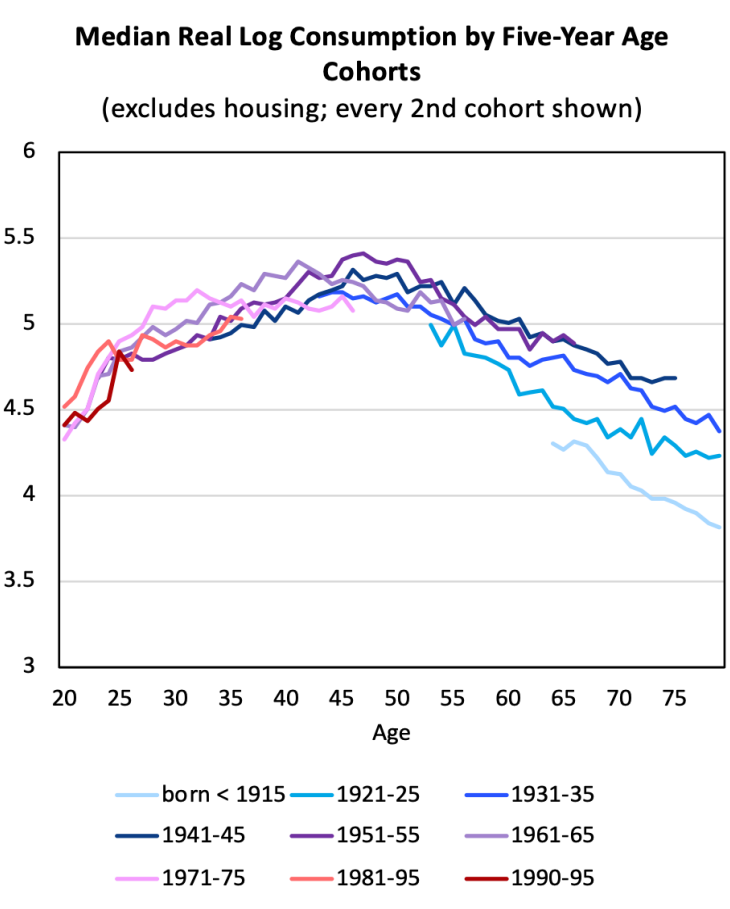
Figure 4



4.3 Aggregate consumption

At the household level, real consumption excluding housing payments such as rent and mortgage interest appear consistent with a life-cycle model, peaking around the age of 45–50 before declining. However, the real non-housing expenditure of younger cohorts born in the 1980s and 1990s is a little lower than older cohorts.

Figure 5



To formalise this observation and identify the deviation of real non-housing consumption from a simple life-cycle model in my sample over time and between cohorts, I follow the methodology of Attanasio et al. (2009) and plot the residuals from simple lifecycle regression of age and demographic variables on non-housing consumption:

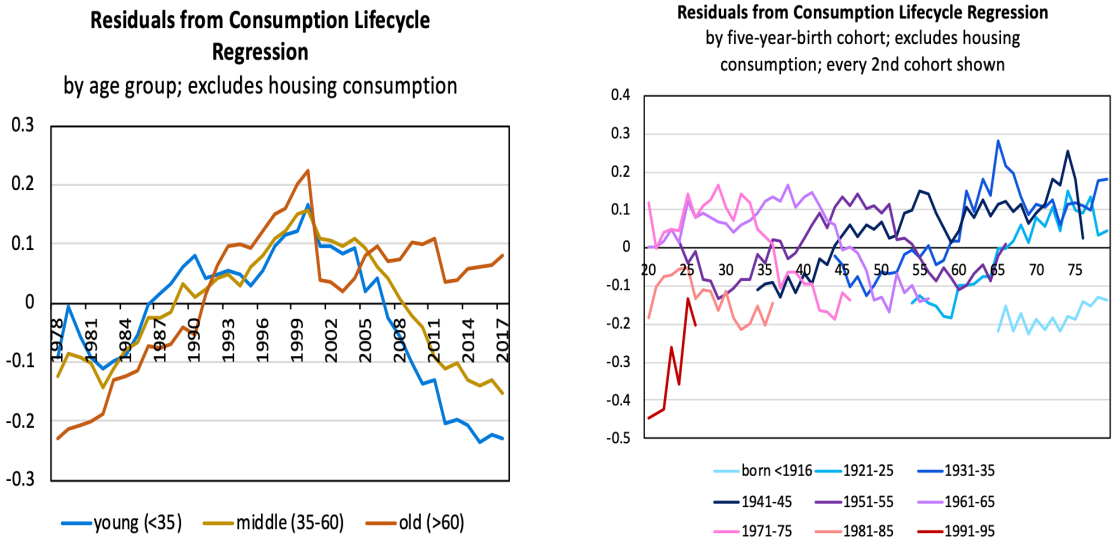
$$\ln X_t^h = a^g + f(age) + \gamma z_t^h + u_t^h$$

where z_t^h is a vector of demographic variables for household h, $f(age)$ is linear function of age and higher power terms (age^2, age^3, age^4 and age^5), and u_t^h is the error term. Positive residuals indicate that consumption is higher than would be predicted by a life-cycle model.

Until 2000, the residuals of this regression are fairly similar for all age groups, but then begin to diverge. Between 2000–2017 the residuals sharply decline for both

the average young and middle-age household. Non-housing consumption by young and middle-aged households has been below the level predicted by a simple life-cycle model since the late 2000s. This decline is broad-based by age cohorts. Over the past 15 years, the residuals have become more negative for all cohorts born after the 1950s despite being at very different stages of the consumption life-cycle. The decline in residuals has been the largest for the young, which is consistent with an increase in housing consumption weighing on non-housing consumption. However, the weakness in non-housing consumption by middle-age households who have much higher rates of homeownership, suggests the contribution of other factors, such weak wage growth post-crisis, de-leveraging, or changes in saving behaviour.

Figure 6



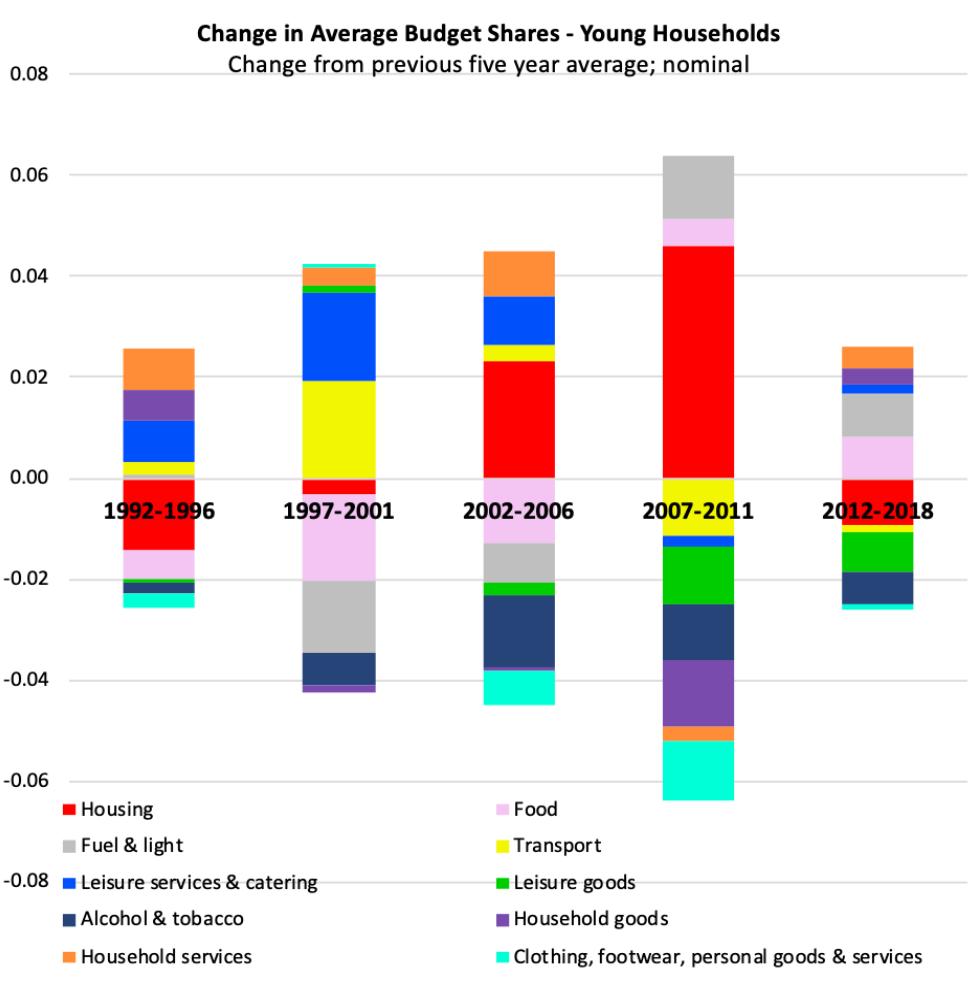
4.4 Budget shares

The share of household budgets allocated to housing and non-housing expenditure has changed over time. Over the sample period, the average housing budget share increased by around one percentage point. This occurred during the housing boom of the early-to-mid 2000s, as well as during the period that included the financial crisis as people cut back on non-essential consumption. The average household increased the share of their budget allocated to services, including leisure services, catering, transport, household services and housing services, and reduced the budget share of

goods, including food, leisure goods, alcohol and tobacco.

Young households made much larger changes to the share of their budget allocated to housing over this period. The average young households' housing budget share increased by over six percentage points during the 2000s, followed by a small decline after the Great Recession. This occurred alongside a decline in the budget share of most other expenditure categories, with the exception of some services (leisure services, catering, household services) during the early-to-mid 2000s, and necessities (food, fuel) during the Great Recession.

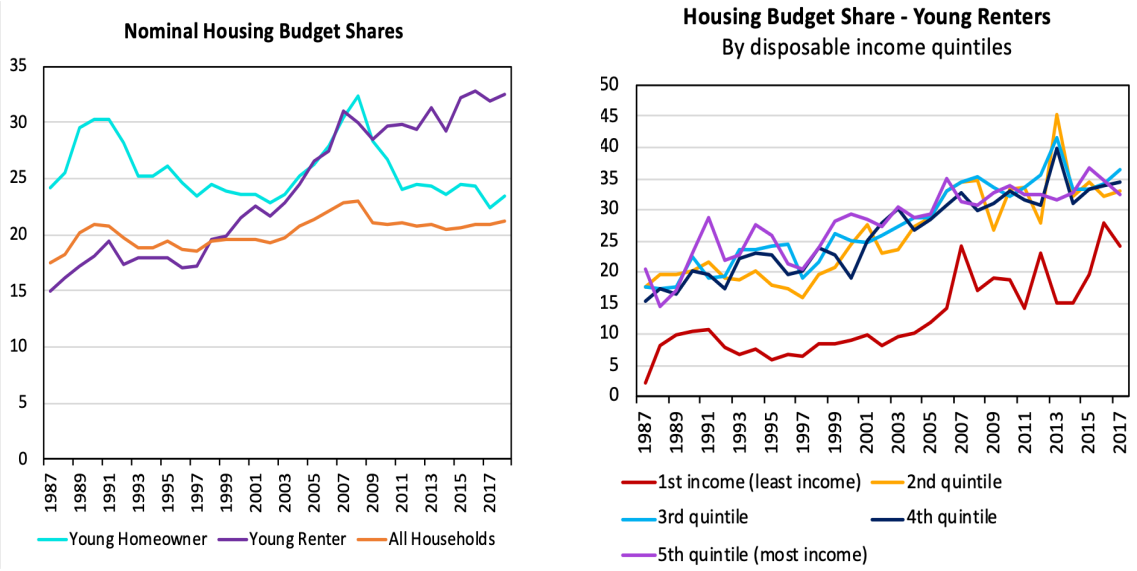
Figure 7



There is an important caveat to this analysis; that the housing expenditure by renters and homeowners in my sample are not directly comparable, and therefore changes in average housing budget shares can be due to tenure compositional changes.

The FES captures actual expenditure so it does not include imputed rent. Imputed rent is required to accurately compare housing services consumption by homeowners to that of renters, which is measured by actual rent paid. Instead, the survey reports the mortgage interest payments (but not capital repayments) as the housing expenditure by homeowners, as well as various housing-related costs (dwelling insurance, repair and maintenance charges, DIY materials, water and sewerage charges, rates and council tax). As a result, the housing budget share for owner-occupiers tracks movements in interest rates as it mostly consists of mortgage interest payments.

Figure 8



However, the large increase in the budget share of housing is not an artefact of compositional changes. It reflects the sharp increase in the budget share renters allocate to housing consumption, which rose from 15 per cent in late 1990s to over 30 per cent in 2017. This increase was broad-based by income quintiles. The housing consumption of those in the lowest quintile likely reflects the provision of social housing. The magnitude and timing of the increase in the average housing budget share of young renters is also quite similar accross the different UK regions, with the exception of London, where the average budget share allocated to housing is higher and increased at a faster pace over the sample period.

5 Aggregate Consumption & House Price Shocks

This section compares the non-housing consumption response of young, middle-age and old households to house price shocks using a life-cycle model. My purpose is to answer my first research question: how has the aggregate level of consumption by young renters responded to house price shocks in the UK over the past forty years? To answer this question, I adopt a modelling approach used by Attanasio et al. (2009), who estimate a life-cycle consumption model to determine whether the co-movement of aggregate consumption and house prices can be better explained by wealth effects, or by a common factor such as income expectations that determine house prices and consumption independently. While this approach does not allow me to consider housing tenure directly, wealth effects and common factors predict a different consumption response by young renters to house price shocks. In addition, by estimating the model using different sample periods and using UK-wide data and data for individual UK regions, I am able to verify whether large differences in homeownership rates affect the results. I find that the common factors explanation better explains my regression results, and this result is robust to different sample periods and UK regions.

5.1 Baseline model

Attanasio et al. (2009) estimate a simple reduced-form equation for the level of household non-housing consumption as a function of age, various demographic terms such as occupation, region, and education, and crucially, an interaction term of regional house price growth interacted with a dummy for age group, which is either young (aged under 35), middle-age (35–60) or old (over 60):

$$\ln X_t^{ch} = \alpha^c + f(age) + \gamma' z_t^{ch} + \theta_{1Y} g(hp_t^r) DY_t^{ch} + \theta_{1M} g(hp_t^r) DM_t^{ch} + \theta_{1O} g(hp_t^r) DO_t^{ch} + \varepsilon_t^c + u_t^{ch}$$

where $\ln X_t^{ch}$ is log real non-housing consumption for household h of cohort c (where five-year cohorts are assigned based on year of birth of household head), $f(age)$ is a function of age of household head and higher power terms (age^2, age^3, age^4 and age^5), z_t^{ch} is a vector of demographic variables, $g(hp_t^r)$ are regional real house prices that are specified either in levels or growth rates, DY_t^{ch}, DM_t^{ch}, DO_t^{ch} are dummies reflecting

whether a household head is young, middle aged or old, and ε_t^c and u_t^{ch} are the error terms. Since they do not have a panel-dataset, Attanasio et al. (2009) control for individual fixed effects by building a pseudo-panel of five-year birth cohorts. Using birth cohort pseudo-panels has become frequently used in the empirical consumption literature, commencing with Browning, Deaton and Irish (1985) and Deaton (1985).

The key identifying assumption of this approach, is that if the relationship between house price growth and consumption is driven by a wealth effect, the coefficients on regional house price terms interacted with age should be larger for older households. Older households have higher rates of home ownership, and due to shorter life expectancies, are more likely to consume any windfall gains. If the relationship is mediated by 'common factors' such as expected future income or productivity, the opposite result is expected. The coefficient for the house price-age interaction term should be larger for younger households, who stand to benefit most from higher future lifetime income[2]. Attanasio et al. (2009) also consider an alternative specification using house price levels. This is to take into account the possibility that it is the level of resources, rather than the growth rate, that should affect the level of consumption, as implied by the Permanent Income Hypothesis (Hall, 1978).

The main finding of Attanasio et al. (2009), is that a one percentage point increase in annual regional house price growth is associated with a 0.2, 0.1, and negligible per cent increase in consumption for households with a young, middle-age and old household head respectively. They interpret these results as evidence for the 'common factor' explanation, as the young, with the lowest rate of homeownership, are the most responsive to house price growth. Their results using house price levels instead of growth rates are less conclusive as there is very little difference in the coefficients for young, middle-age and old households. Attanasio et al. (2009) argue that the house price levels specification may just be capturing other regional differences, and that their preferred specification uses housing growth rates.

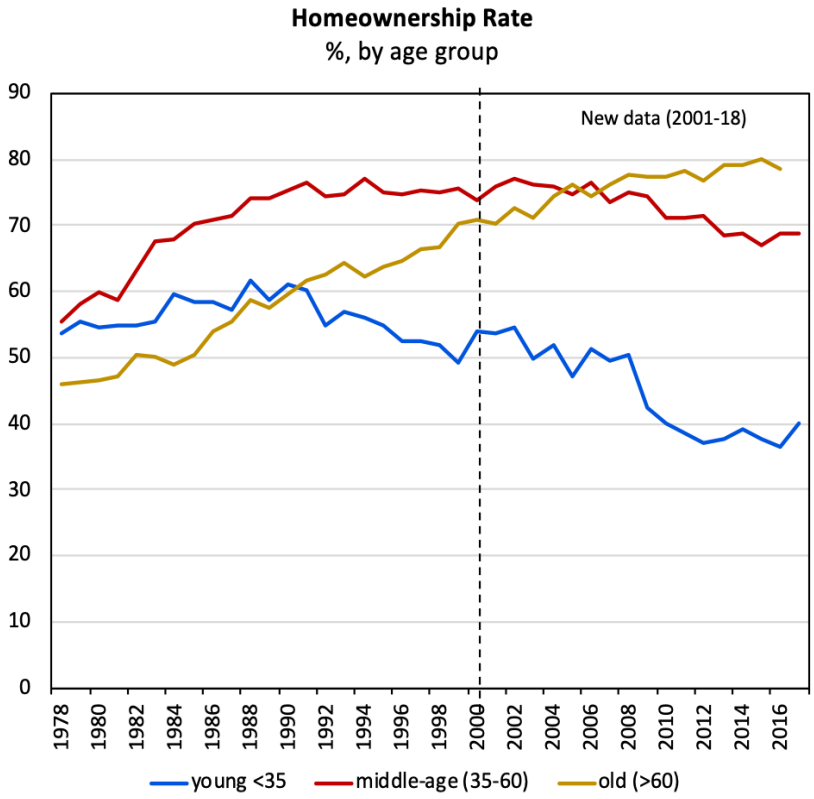
If 'common factors' such as income expectations were the key cause of the co-movement of consumption and house prices in the UK over the 1978–2000 period, then young households, both renters and homeowners should, on average, increase their consumption when house prices rise. However, house price shocks do not cause this change in consumption; a change in income expectations causes both house prices

[2]Authors use a different specification to investigate the collateral channel; their results are mixed

and consumption to change independently. There may be some differences between the consumption response of young renters and young homeowners if income expectations differ systematically between the two groups. In addition, this does not negate the possibility of some young households directly responding to house price shocks by changing their consumption. Since house prices grew faster than the income of young households over this period, some young renters may have modified their homeownership aspirations and changed their saving and consumption behaviour accordingly.

I re-estimate Attanasio et al. (2009)'s baseline model to determine whether their results are robust to an additional 17 years of data. In addition, I estimate this model over different sample periods with different homeownership rates to determine whether the decline in youth homeownership is associated with any changes to the magnitude of the consumption elasticity responses. Attanasio et al. (2009) chose to not include surveys that were published after the 2000/01 Family Expenditure Survey because the ONS significantly changed the structure of their household consumption expenditure survey in 2001. I am able to extend their sample up to the 2017/18 Living Cost and Food Survey by using an IFS dataset that adjusts the post-2000 data to be consistent with the older survey design. The additional data enables me to incorporate a period when a large decline in youth homeownership occurred into my sample.

Figure 9



I estimate a consumption life-cycle model on four different sample periods: the full sample (1978–2018 Q1), the original sample period used by Attanasio et al. (2009) (1978–2000), a sample that begins in 1992 to capture the period when the homeownership rate of young people first started to decline, and a sample that begins in 2001 to capture the period when the decline in youth homeownership accelerated. The 1992–2017 sample was also chosen to exclude the mid-to-late 1980s as Attanasio et al. (2009) find this period generates very large residuals, possibly due to the financial liberalisation during this period causing a level shift in consumption. Full regression results are reported in *Appendix 9.2*.

Table 2 reports the coefficients of the house price-age group interaction terms for the four different sample periods I use to estimate the model (I, II, III, IV). These coefficients can be interpreted as the elasticity of non-housing consumption to house prices growth. I also estimate an alternate specification using house price levels. The results from this alternate specification are similar to Attanasio et al. (2009) and are

reported in *Appendix 9.3.*

Table 2: Non-Housing Consumption Elasticity to Annual Real House Price Growth

Variable	**I** (1978-2017)	**II** (1978-2000)	**III** (1992-2017)	**IV** (2001-2017)
House price x young	0.219*	0.142*	0.548*	0.205*
	[0.0238]	[0.0258]	[0.0405]	[0.0547]
House price x middle-age	0.242*	0.071*	0.383*	0.067*
	[0.0163]	[0.0190]	[0.0252]	[0.0329]
House price x old	0.064*	-0.032	0.147*	-0.004
	[0.0194]	[0.0221]	[0.0321]	[0.0419]

* is significant at p=0.05; standard errors in brackets

Regardless of sample period used, the non-housing consumption elasticity of house price growth is smallest for old households, and is typically largest for young households. An exception is for the full 1978–2018 sample, where a hypothesis that the coefficient on the young and middle age are the same could not be rejected. These results support the conclusion of Attanasio et al. (2009); that common factors can better explain the relationship between consumption and house prices than housing wealth effects. A possible explanation for the level differences in the coefficients estimated over different sample periods, are asymmetries in the consumption response to housing price upswings and downswings. The sample periods vary in the number of years of strong house price growth, weak house growth and recessions they contain. These results are robust to large declines in the homeownership rate of young people. The homeownership rate falls from 56 per cent for the 1978–2000 sample to 46 per cent for the 2001–2017 sample, with little difference in the coefficient estimates, suggesting that these tenure shifts do not materially change the results.

There are some differences between my coefficients and those estimated by Attanasio et al. (2009) using the same sample period. This likely reflects some differences in data sources and model specification. My regional house price data is from Nationwide, while Attanasio et al. (2009) use local government data. There are some differences in how I code some of the demographic variables, for example, I use a smaller number of dummies for children of different ages. Overall though, the Attanasio et al. (2009) results can be successfully replicated and I conclude that, on

average, young renter households in the UK have increased their non-housing consumption when house prices rise, but this is not primarily due to a causal relationship between consumption and house prices.

5.2 Regional heterogeneity

I investigate the robustness of my results to regional variation in house price growth and homeownership rates by re-estimating my baseline model for each of the 10 regions in the UK, excluding Northern Ireland and combining the South East and Eastern regions.[3] For each region, I report the coefficient on the house-price-age group interaction term estimated over both the full sample, and a reduced sample that begins in 1992 to focus on the period of declining homeownership. If the co-movement of consumption and house prices is caused by common factors such as income expectations, I would expect a high degree of similarity between regional results because a large component of income expectations reflect national economic conditions, while wealth effects reflect differences between local housing market conditions. I report the coefficient estimates for the two sample periods in *Table 3* and *Table 4*, and include average annual house price growth and the average percentage point difference in homeownership rates between the young and middle age households for each region.

[3]Prior to 2001, the survey data I use reported standard statistical regions, which preceded the government office regions for statistics. The new government regions moved Cumbia from the north east (previously called north) region to the north west region. The population of Cumbia is small and so this has little impact on my analysis. A larger change was made to the eastern region (previously called 'East Anglia') and south east region. Bedfordshire, Essex and Hertfordshire were moved from the latter to the former region. Because I am not able to convert pre-2001 regional data to the new regions, I combine these two regions in my analysis.

Table 3: Consumption Elasticity to Annual Real House Price Growth - 1978-2018

Region	Young	Middle	Old	House price (%)	Homeownership young - middle-age (ppts)
London	0.198*	0.133*	-0.025	4.42	-0.19
	[0.071]	[0.054]	[0.067]		
South East & Eastern	0.153*	0.203*	0.064	3.73	-0.19
	[0.047]	[0.032]	[0.038]		
South West	0.203*	0.241*	0.053	3.58	-0.21
	[0.079]	[0.053]	[0.059]		
East Midlands	0.133	0.136*	-0.104	3.20	-0.18
	[0.081]	[0.054]	[0.066]		
North West & Merseyside	0.363*	0.388*	0.051	3.05	-0.17
	[0.072]	[0.051]	[0.060]		
West Midlands	0.121*	0.271*	0.044	2.99	-0.20
	[0.079]	[0.053]	[0.065]		
Wales	0.3578*	0.2418*	0.163*	2.60	-0.21
	[0.105]	[0.067]	[0.078]		
Yorkshire & the Humber	0.306*	0.357*	0.092	2.49	-0.18
	[0.072]	[0.050]	[0.059]		
North East	0.274*	0.260*	0.137	2.25	-0.14
	[0.107]	[0.073]	[0.084]		
Scotland	0.456*	0.408*	0.343*	1.81	-0.14
	[0.119]	[0.079]	[0.095]		

* = significant at p=0.05; standard errors in brackets

Attanasio et al. (2009)'s key result; that the consumption of the oldest age group is less responsive to house price growth than the young and middle-age groups, continues to hold across all regions when each region is estimated separately.

Table 4: Consumption Elasticity to Annual Real House Price Growth - 1992-2018

Region	Young	Middle	Old	House price (%)	Homeownership young - middle-age (ppts)
London	0.688*	0.331*	0.060	3.98	-0.24
	[0.126]	[0.089]	[0.120]		
South East & Eastern	0.383*	0.329*	0.090	3.16	-0.25
	[0.006]	[0.071]	[0.044]		
South West	0.483*	0.501*	0.142	3.11	-0.26
	[0.134]	[0.081]	[0.092]		
Wales	0.657*	0.303*	0.190	2.24	-0.25
	[0.170]	[0.100]	[0.126]		
East Midlands	0.462*	0.435*	0.029	2.20	-0.25
	[0.142]	[0.087]	[0.111]		
West Midlands	0.476*	0.283*	-0.066	1.86	-0.26
	[0.143]	[0.090]	[0.112]		
Scotland	0.420*	0.382*	0.309*	1.75	-0.20
	[0.172]	[0.105]	[0.130]		
Yorkshire & the Humber	0.626*	0.519*	0.206*	1.74	-0.25
	[0.127]	[0.079]	[0.097]		
North west & Merseyside	0.603*	0.506*	0.237*	1.72	-0.22
	[0.119]	[0.075]	[0.096]		
North East	0.503*	0.276*	0.291*	1.01	-0.22
	[0.164]	[0.101]	[0.125]		

* = significant at p=0.05; standard errors in brackets

There is a upward level shift in the magnitude of all the age-house price interaction coefficients when I reduce the sample period to 1992–2017. Removing 1978–1991 from the sample period also increases the consumption elasticity estimates for young households by more than those for middle-age and old households. As a result, the young household consumption elasticity estimates are larger than those for the middle-aged for all regions except for the south west when estimated using the 1992–2017 sample. This does not occur when the full 1978–2017 sample is used; the young and middle-age estimates are very similar for most regions. The period of 1978–1991 that I exclude includes two recessions (1980Q1–1981Q1 and 1990Q3–1991Q3). Therefore, a possible explanation for the larger consumption elasticity estimates for the young,

is that young people's consumption is more responsive during periods of house price upswings. For example, young households may respond to an increase in their income expectations by increasing their consumption, but are less willing to decrease their consumption when their income expectations decrease, relative to older households. Further research should be done to explore this potential asymmetry.

It is interesting to note that London has the lowest level of homeownership by young people, averaging 40 per cent over the 1992–2017 sample period, the highest house price growth, and the largest consumption elasticity estimates for young households. Therefore, the larger consumption elasticity estimates for young households relative to older households are robust to samples that consist mostly of renters. However, there is no obvious relationship between the magnitude of the estimated coefficients and house price growth in different regions. The variation in homeownership rates between most regions is small; the decline in homeownership by young people has been a national trend.

I conclude that the answer to my first research question on how the aggregate quantity of non-housing consumption by young UK renters responded to house price shocks, is that young people increased their non-housing consumption when house prices rose. However, this co-movement does not indicate a causal relationship. Instead, common factors such as income expectations caused the majority of this co-movement. Since the life-cycle model I estimated excluded housing consumption, the implication of this result on tenure choices are unclear, and depend on intra-temporal elasticities between housing and non-housing consumption, as well as the income elasticity of housing. In the next chapter I estimate a demand system that can be used to calculate some of these elasticities.

6 Demand System Estimation

In the previous chapter, I concluded that on average, young renters in the UK increased their non-housing consumption when house prices rose in the 1978–2017 period. This chapter addresses the second key research question of this thesis: how have high house prices affected the allocation of consumption between the major expenditure categories by young renters? To answer this question, I estimate the housing cross-price elasticity of demand for the major expenditure categories, and the income/expenditure elasticity of housing. To calculate these elasticities I estimate an Almost Ideal Demand System.

In the next sections, I describe the theoretical properties of AIDS, how I estimate it using my dataset, and the resulting elasticity estimates.

6.1 Demand system theory

The Almost Ideal Demand System (AIDS) is the most widely used method of estimating demand functions, and has severable desirable traits. These are summarised by Deaton and Muellbauer (1980*a*, p. 132) as *"[it] gives an arbitrary first-order approximation to any demand system; it satisfies the axioms of choice exactly; it aggregates perfectly over consumers without invoking parallel linear Engel curves; it has a functional form which is consistent with known household-budget data; it is simple to estimate, largely avoiding the need for non-linear estimation; and it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters."* The derivation of AIDS demand functions is a fairly simple application of consumer theory. A full derivation can be found in Deaton and Muellbauer (1980*a*), I provide a brief summary of the approach in *Appendix 9.4*. Starting with an expenditure function, Deaton and Muellbauer (1980*a*) derive Marshallian demand equations expressed in terms of expenditure (budget) shares $w_i = x_{it}p_{it}/m_t$:

$$w_{it} = \alpha_i + \sum_j \gamma^*_{ij} + \ln p_{jt} + \beta_i \ln\left(\frac{m_t}{P_t}\right)$$

where $\gamma^*_{ij} = \frac{1}{2}(\gamma_{ij} + \gamma_{ji})$, which equals γ_{ij} if symmetry is imposed, p_{it} is the price of good i at time t, x_{it} is real household expenditure for good i, m_t is total nominal expenditure, α, β and γ are coefficients to estimate, and P_t is a translog price index

such that $\ln P_t = \alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2} \sum_i \sum_j \left(\frac{1}{2}(\gamma_{ij} + \gamma_{ji})\right) \ln p_{it} \ln p_{jt}$.

The following demand function properties must hold to make the estimated model consistent with demand theory (Deaton and Muellbauer, 1980*b*):

1. Adding-up condition: expenditure budget shares always sum to one. Requires $\sum_i \alpha_i = 1$, $\sum_i \beta_i = 0$ and $\sum_i \gamma_{ij} = 0 \ \forall j$

2. Homogeneity condition: homogeneity of degree zero in total expenditure and prices. Requires $\sum_i \gamma_{ij} = 0 \ \forall i$. It also implies that the sum of uncompensated and income elasticities equal zero.

3. Symmetry condition: cross-price derivatives of Hicksian demand function are equal. Requires $\gamma_{ij} = \gamma_{ji} \ \forall \ i \neq j$

4. Positivity: No negative prices

5. Monotonicity: First-order derivatives of the cost function must be non-negative. This is satisfied if the estimated budget shares are positive.

6. Curvature/Negativity: Hessian matrix of expenditure function is negative semidefinite. Implies that Hicksian own-price elasticities are not positive.

The adding-up condition is automatically satisfied as, by definition, observed budget shares always sum to one (Deaton and Muellbauer, 1980*b*). Symmetry and the adding-up condition together imply homogeneity; both can be imposed in model estimation. I do not observe any negative prices in my dataset. I do not impose the requirements of monotonicity or curvature, but I subsequently check my elasticity estimates for any violations.

The simplest way to estimate an AIDS model is to take a linear approximation of the translog price index, such as by using a Stone index. However, there are multiple empirical limitations of this approach, including the risk of simultaneity bias, non-invariance to the unit of measurement, and approximation errors (Henningsen, 2015). In addition, AIDS implies expenditure share Engel curves that are linear in the log of total expenditure. Banks, Blundell and Lewbel (1997) find evidence of curvature in the Engel curves of some commodities, calculated using the same UK FES data that I use. Imposing linear Engel curves in this situation will distort welfare analysis that considers the distributional consequences of house price changes that I compute in a

subsequent chapter. As a result, I choose to estimate a non-linear AIDS model that includes a quadratic term in the log of expenditure to the demand equation, scaled by the Cobb-Douglas price aggregator $\prod_i p_{it}^{\beta_i}$. The extra quadratic term permits goods to be necessities at some income levels and luxuries at other income levels. I estimate the following 'Quadratic Almost Ideal Demand System' (QUAIDS):

$$w_{it} = \alpha_i + \sum_j \gamma_{ij}^* \ln p_{jt} + \beta_i \ln \left(\frac{m_t}{P_t} \right) + \frac{\lambda_i}{\prod_i p_{it}^{\beta_i}} \left[\ln \left(\frac{m_t}{P_t} \right) \right]^2$$

I estimate a QUAIDS model using the Stata *quaids* package that uses the iterated feasible generalized nonlinear least-squares estimator, which is equivalent to using a multivariate normal maximum-likelihood estimator (Poi, 2012).

Since I estimate household-level budget shares, it is important to adjust for household composition, such as household size and the number of children. I follow a commonly-used technique first described by Ray (1983) that treats demographic variables as a scaling function. The main assumption of this approach is that the impact of demographic variables on budget shares is independent of total expenditure, although there is some evidence that this assumption may downwardly bias the point estimates if the impact of demographic variables decreases as total expenditure increases (Blow, 2003). I provide further technical details in *Appendix 9.4*.

6.2 QUAIDS estimation

To estimate a Quadratic Almost Ideal Demand System, I make the following modelling choices. I exclude durable (household) goods because durable goods provide a consumption flow over many time periods. Estimating a demand system with non-durable consumption expenditure is consistent with assuming the utility function has weak separability between total consumption of durable and non-durable goods (Deaton and Muellbauer, 1980*b*)

I address censored observations by aggregating expenditure categories to reduce their occurrence. A significant fraction of households consume zero goods from one or more expenditure categories. These corner solutions may bias coefficient estimates as zero observations are implicitly non-positive consumption choices that are censored to be non-negative. Utility consistent approaches to deal with this issue exist. Lee and

Pitt (1986) construct virtual prices which would induce households to consume exactly zero of that commodity, so that the commodity is no longer censored. Simulated method of moments estimators can also be used (Noriko Amano-Patiño, 2019). A simpler solution suffices for my purposes. I construct three amalgamated variables to reduce the number of censored observations. Retail price indices for these new variables are constructed as an average of the component indices weighted by budget shares. I then remove households with zero expenditure in any of the six budget shares. In total this loses seven per cent of households in the sample, of these under 25 per cent are young households. I also remove households who report negative expenditure for any budget share.

Table 5: Amalgamated Consumption Categories

New categories	Components	Share zero observations (%)
Food	food	0.42
Housing	housing	1.07
Fuel & light	fuel & light	2.93
Leisure	leisure goods, leisure services, catering	0.39
Other goods	clothing & footwear, personal goods & services, tobacco, alcohol	2.73
Transport & other services	household services, fares, motoring	1.07

I include four demographic variables as scaling factors: number of children in household, number of adults in household, region and cohort. Scaling by region helps control for differences in house prices between regions as I only have national retail price indices. Cohorts are defined as five-year birth cohorts. More complex demand system models can include dynamic elements, such as a term to capture past consumption as a 'habit' (Blanciforti, Green and King, 1986). Including a cohort demographic variable can be considered a crude time-trend.

Estimating the model requires the value of α_0 to be specified. Deaton and Muellbauer (1980a) note that the practical identification of α_0 is problematic. Since it can be interpreted as the consumption required for a minimal standard of living when prices are unity, a common approach is to set α_0 to be a little below the lowest value

of the log of total expenditure observed in the data (Banks, Blundell and Lewbel, 1997). Following this approach, I set α_0 to be equal to zero.

I impose symmetry, and therefore homogeneity, on my model. As a robustness check, I estimate an unrestricted model and test for symmetry and homogeneity. A visual inspection of the results indicates that monotonicity is satisfied as all estimated budget shares are positive.

I estimate a QUAIDS model twice; using the full sample, and using a sub-set of the sample to just include young households with a household head aged under 35. The estimated coefficients from these two models are reported in *Table 6* and *Table 7*. In these tables, α is the intercept, β_i is the expenditure coefficient that captures the change in the budget share of good i with respect to a one per cent change in total expenditure, γ_{ji} are price coefficients and represent the change in budget share of good i in response to a one per cent change in the price of good j, and ρ are scaling factors that account for demographic variables. If $\beta > 0$, a good is a luxury while if $\beta < 0$ a good is a necessity. If $\gamma_{ji} > 0$, then goods i and j are substitutes, and if $\gamma_{ji} < 0$, then goods i and j are complements.

Table 6: Parameter estimates of QUAIDS estimation - Full sample

$Good_i$	α_i	β_i	γ_{1i} (food)	γ_{2i} (house)	γ_{3i} (fuel)	γ_{4i} (leisure)	γ_{5i} (goods)	γ_{6i} (services)	λ	no. kids	no. adults	cohort	region
Food	0.812*	-0.205*	-0.082*	.	.	.	.	.	0.013*	0.002*	0.001*	-0.001*	0.000*
	[0.006]	[0.003]	[0.005]	.	.	.	.	.	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Housing	-0.239*	0.221*	0.138*	-0.072*	.	.	.	.	-0.029*	-0.006*	-0.002*	0.002*	0.000*
	[0.009]	[0.004]	[0.003]	[0.005]	.	.	.	.	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Fuel	0.559*	-0.181*	-0.080*	0.067*	-0.048*	.	.	.	0.017*	-0.002*	-0.001*	0.000*	0.000
	[0.004]	[0.001]	[0.002]	[0.002]	[0.001]	.	.	.	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Leisure	0.088*	-0.044*	-0.119*	-0.026*	-0.019*	0.214*	.	.	0.017*	0.000*	0.003*	-0.001*	0.000*
	[0.009]	[0.005]	[0.005]	[0.004]	[0.002]	[0.009]	.	.	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Other	-0.131*	0.149*	0.165*	-0.081*	0.040*	-0.177*	0.086*	.	-0.018*	0.003*	-0.001*	0.000*	0.000*
goods	[0.008]	[0.004]	[0.004]	[0.003]	[0.002]	[0.005]	[0.006]	.	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Other	-0.088*	0.061*	-0.022*	-0.027*	0.040*	0.126*	-0.033*	-0.085*	0.000	0.002*	0.001*	0.000*	0.000*
services	[0.010]	[0.005]	[0.006]	[0.004]	[0.003]	[0.008]	[0.007]	[0.014]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
ρ (scaling)	.	.	.	.	.	.	.	.	.	0.596*	0.576*	-0.028*	0.005*
	.	.	.	.	.	.	.	.	.	[0.017]	[0.012]	[0.001]	[0.002]

* = significant at p=0.05; standard errors in brackets

Table 7: Parameter estimates of QUAIDS estimation - Young households

$Good_i$	α_i	β_i	γ_{1i} (food)	γ_{2i} (house)	γ_{3i} (fuel)	γ_{4i} (leisure)	γ_{5i} (goods)	γ_{6i} (services)	λ	no. kids	no. adults	cohort	region
Food	0.492*	-0.148*	-0.014	.	.	.	.	.	0.015*	0.005*	-0.001*	-0.002*	0.000
	[0.018]	[0.006]	[0.011]	.	.	.	.	.	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Housing	-0.199*	0.325*	0.076*	0.006	.	.	.	.	-0.057*	-0.001*	-0.008*	-0.001*	0.001*
	[0.030]	[0.011]	[0.009]	[0.018]	.	.	.	.	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Fuel	0.318*	-0.125*	-0.017*	0.060*	-0.008*	.	.	.	0.016*	-0.001*	-0.004*	-0.001*	0.000*
	[0.015]	[0.005]	[0.004]	[0.007]	[0.003]	.	.	.	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Leisure	0.137*	-0.071*	-0.023*	-0.034*	-0.039*	0.037	.	.	0.019*	-0.001*	0.005*	0.002*	0.000
	[0.007]	[0.006]	[0.010]	[0.008]	[0.004]	[0.020]	.	.	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Other	0.238*	-0.017*	0.057*	-0.050*	-0.016*	-0.134*	0.158*	.	0.002	0.001*	-0.001*	0.000	0.000*
goods	[0.007]	[0.005]	[0.009]	[0.007]	[0.003]	[0.013]	[0.015]	.	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Other	0.014	0.037*	-0.080*	-0.059*	0.020*	0.193*	-0.016	-0.060	0.005*	-0.003*	0.009*	0.001*	0.000
services	[0.011]	[0.007]	[0.013]	[0.008]	[0.005]	[0.020]	[0.017]	[0.032]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
ρ (scaling)	.	.	.	.	.	.	.	.	.	1.504*	3.977*	0.213*	0.063*
	.	.	.	.	.	.	.	.	.	[0.188]	[0.419]	[0.033]	[0.015]

* = significant at p=0.05; standard errors in brackets

6.3 Elasticity estimates

My purpose in estimating QUAIDS models is to obtain elasticity estimates, which I use to answer the second research question of this thesis on how house prices growth changed how young renters allocate consumption between major expenditure categories. In this section, I report income elasticities, which estimate the impact of a change in total income on the quantity demand of a good, and compensated (Hicksian) price elasticities, which estimate the impact of the change in the price of a good on the demand of that good (own-price) or another good (cross-price) in the demand system, holding total utility constant. For brevity, I do not report uncompensated (Marshallian) price elasticities. Formulas to calculate these elasticities from QUAIDS coefficient estimates are provided in *Appendix 9.5*. Standard errors are taken from the QUAIDS estimation and are calculated using the asymptotic variance–covariance matrix described in Blundell and Robin (1999).

I report two sets of elasticities: elasticities calculated using coefficients from the QUAIDS model estimated on my entire sample, and coefficients estimated only using young households data. Both sets of elasticity estimates are broadly consistent with economic theory. Income elasticities (μ_i) are all positive, indicating that the six commodities in my demand system are normal goods. Food and fuel & light are necessities ($\mu_i < 1$), leisure and transport and other services are luxuries ($\mu_i > 1$), and the income elasticities of housing and other goods are around unity. Compensated own-price elasticities are negative for all goods, with the exception of leisure which is negative when calculated using the young household sample but positive for the entire sample. Therefore, negative/curvature demand property is only satisfied for the QUAIDS model estimated using young households.

The elasticities calculated using the entire sample are similar to the elasticities calculated using the young household sample. The biggest differences arise from the leisure and housing elasticities. This is unsurprising; over the sample period, there is a large divergence in leisure and housing budget shares of young and older households. The leisure budget share of young households declined from the early 2000s until the Great Recession, while it remained fairly stable at a higher level for older households. Young households allocated a much higher share of their budget to housing relative to older households, and the difference between these age groups increased.

Table 8: Mean Elasticity Estimates - Income & Compensated Price
By age group

	Food		Housing		Fuel		Leisure		Other Goods		Other Services	
	all	young	all	young	all	young	all	young	all	young	all	young
Income	0.436*	0.395*	0.933*	0.985*	0.244*	0.237*	1.450*	1.350*	1.008*	0.959*	1.322*	1.381*
	[0.002]	[0.005]	[0.002]	[0.006]	[0.003]	[0.010]	[0.003]	[0.007]	[0.003]	[0.007]	[0.003]	[0.007]
Food price	-0.679*	-0.945*	0.350*	0.318*	0.443*	0.537*	-0.452*	-0.01	0.669*	0.570*	-0.038	-0.321*
	[0.030]	[0.083]	[0.041]	[0.099]	[0.045]	[0.107]	[0.046]	[0.112]	[0.047]	[0.117]	[0.043]	[0.110]
Housing price	0.432*	0.527*	-0.563*	-0.679*	0.032	1.033*	-0.150*	0.125*	0.104*	0.03 0	0.257*	-0.029
	[0.013]	[0.032]	[0.017]	[0.039]	[0.019]	[0.040]	[0.019]	[0.044]	[0.020]	[0.046]	[0.018]	[0.043]
Fuel price	0.164*	0.232*	0.010	0.269*	-0.356*	-0.475*	0.000	-0.132*	-0.092*	-0.217*	0.037*	-0.034
	[0.008]	[0.023]	[0.011]	[0.027]	[0.012]	[0.029]	[0.012]	[0.031]	[0.013]	[0.032]	[0.012]	[0.030]
Leisure price	-0.517*	-0.012	-0.139*	0.097	-0.001	-0.391*	0.668*	-0.141	-1.059*	-1.272*	0.760*	1.153*
	[0.036]	[0.097]	[0.050]	[0.115]	[0.054]	[0.125]	[0.055]	[0.130]	[0.057]	[0.136]	[0.052]	[0.128]
Other goods price	0.647*	0.671*	0.082	0.022	-0.241*	-0.589*	-0.895*	-1.171*	-0.734*	-0.473*	0.861*	1.088*
	[0.039]	[0.106]	[0.054]	[0.125]	[0.059]	[0.136]	[0.060]	[0.142]	[0.062]	[0.148]	[0.056]	[0.139]
Other services price	-0.048	-0.474*	0.260*	-0.026	0.124	-0.115	0.830*	1.329*	1.111*	1.361*	-1.877*	-1.856*
	[0.056]	[0.143]	[0.077]	[0.170]	[0.083]	[0.184]	[0.085]	[0.193]	[0.088]	[0.201]	[0.080]	[0.189]

* = significant at p=0.05; standard errors in brackets; calculated using Stata aidsills package

The income and compensated cross-price elasticity point estimates calculated using young household data seem reasonable and are broadly consistent with consumer demand theory and other elasticity estimates calculated using AIDS models (for example Banks, Blundell and Lewbel (1997), and Deaton and Muellbauer (1980*a*)). This suggests that the demand system I estimate is not significantly misspecified, allowing me to disaggregate these point estimates to investigate changes to elasticity estimates over time, and compare the median elasticities of different sub-groups, such as young renters and homeowners.

I calculate the income and compensated cross-price elasticity of demand for each individual young household in my sample.[4] I report the median income and compensated own-price elasticity estimates for young renters and young homeowners in *Table 9*. Of particular interest are the compensated housing cross-price elasticities of demand for the six expenditure groups for young homeowners and renters. Therefore, I include graphs of these elasticities over time for young renters and homeowners.

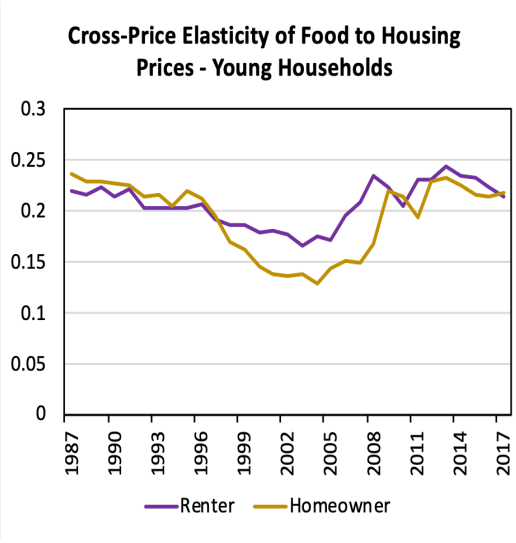
I report median estimates to reduce bias from extreme outliers caused by budget shares close to zero, which result in estimated elasticities for those households that tend to infinity. A consequence of reporting median estimates, is that while the own-price elasticity of 'other goods' is negative and significant for the average young household, it is positive for the median young homeowner and renter. This variability may be caused by the method used to construct the 'other good' price index. The price index is a weighted average of its component retail price indices. However, the variance of these component price indices is large, and includes tobacco that has experienced a 700 per cent price increase over the sample period, and clothing which experienced deflation for around half of the sample period. Since many households do not consume all items in this aggregate category, the price index assigned to it may not accurately represent the prices faced by some households. For example, if a household only buys clothes, a price index that includes tobacco prices may significantly overstate the prices faced by that household. Due to these issues, I do not further examine cross-price elasticity trends for this good.

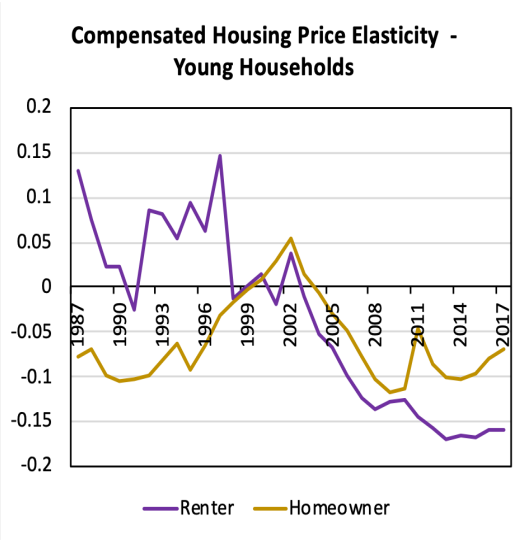
[4]This analysis requires me to use a different Stata statistical package: *quaids* instead of *aidsills*. *Aidsills* uses an iterated linear least-squares estimator (Blundell and Robin, 1999), while *quaids* uses an iterated feasible generalized nonlinear least-squares estimator. Due to the different estimation techniques, the elasticities I report differ by a small amount.

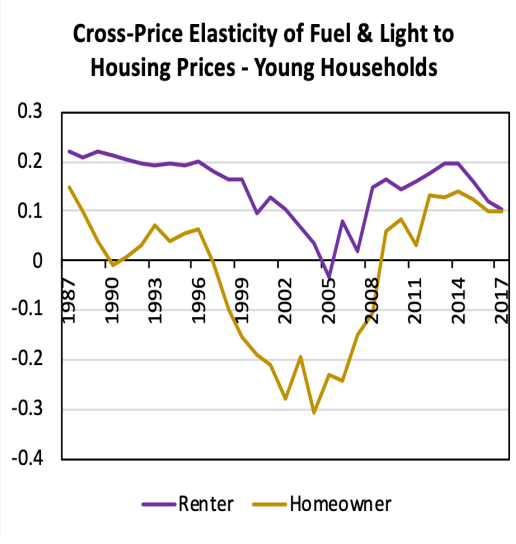
Table 9: Median Income & Compensated Price Elasticity Estimates - Young Households
By Tenure

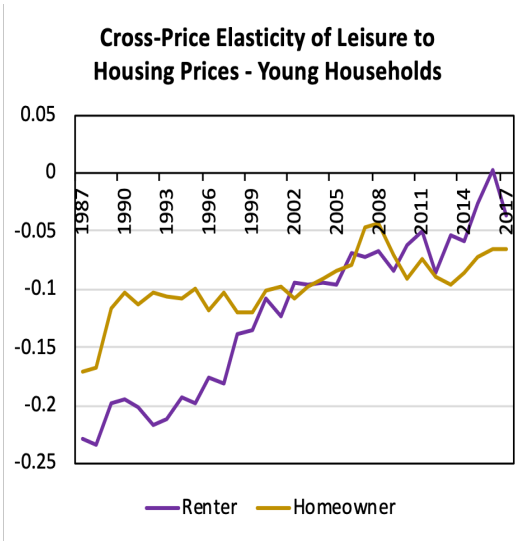
	Food		Housing		Fuel		Leisure		Other Goods		Other Services	
	own	rent	own	rent	own	rent	own	rent	own	rent	own	rent
Income	0.280	0.335	0.926	1.130	-0.119	-0.056	1.404	1.325	0.943	0.938	1.383	1.501
Food price	-0.500	-0.571	0.078	0.136	0.835	0.575	-0.021	-0.009	0.579	0.577	-0.368	-0.487
Housing price	0.198	0.207	-0.066	-0.058	-0.008	0.176	-0.103	-0.138	-0.172	-0.173	0.066	-0.035
Fuel price	0.283	0.235	-0.002	0.039	-0.208	-0.477	-0.163	-0.168	-0.045	-0.023	0.053	0.078
Leisure price	-0.017	0.000	-0.072	-0.092	-0.763	-0.506	-0.523	-0.532	-0.772	-0.661	1.140	1.445
Other goods price	0.772	0.634	-0.100	-0.124	-0.154	-0.061	-0.650	-0.700	0.278	0.147	0.041	0.035
Other services price	-0.749	-0.541	0.051	-0.015	0.322	0.260	1.460	1.507	0.064	0.026	-1.009	-1.167

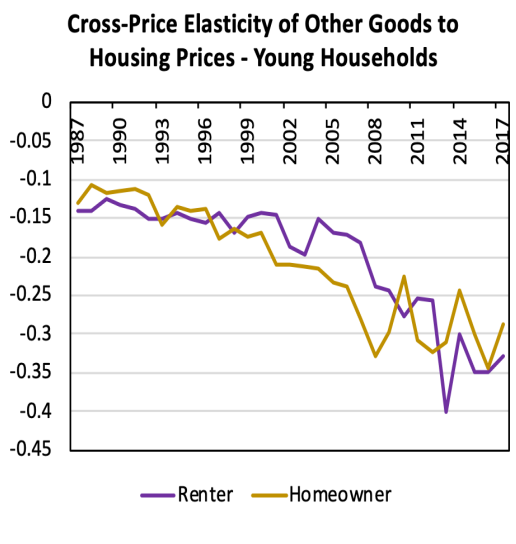
Standard errors unavailable as elasticities calculated using Stata quaids package

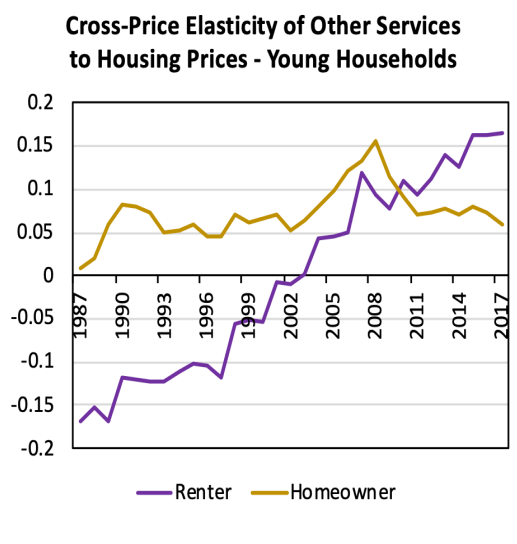

Cross-Price Elasticity of Food to Housing Prices - Young Households
0.3
0.25
0.2
0.15
0.1
0.05
0
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Renter
Homeowner


Compensated Housing Price Elasticity - Young Households
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Renter
Homeowner


Cross-Price Elasticity of Fuel & Light to Housing Prices - Young Households
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Renter
Homeowner


Cross-Price Elasticity of Leisure to Housing Prices - Young Households
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Renter
Homeowner


Cross-Price Elasticity of Other Goods to Housing Prices - Young Households
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Renter
Homeowner

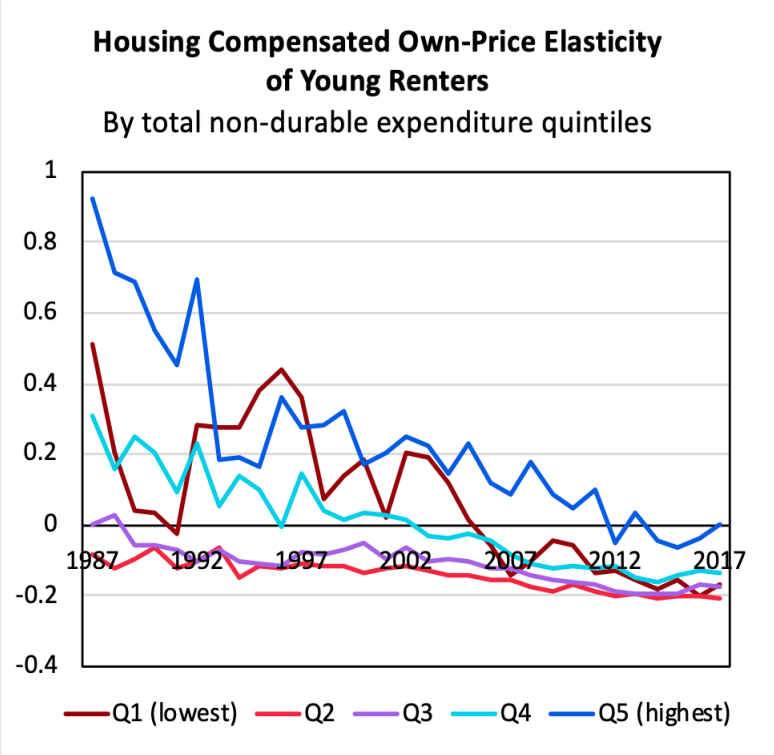

Cross-Price Elasticity of Other Services to Housing Prices - Young Households
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Renter
Homeowner

Changes in the housing cross-price elasticities of demand for food, fuel & light and other goods over the sample period are similar for renters and homeowners. However, there are some differences for housing, leisure, and transport & other services. The housing cross-price elasticity of demand for both leisure, and transport & other services increased sharply for renters over the sample period, while it remained fairly stable for homeowners, except for a small increase during the financial crisis. To better understand how high house prices have influenced the demand by young renters for housing, leisure, and transport & other services, I examine these elasticities in additional detail.

6.3.1 Housing

The compensated housing own-price elasticity sharply declined over the sample period for renters. To investigate how this decline varied between higher- and lower-spending households, I calculate the median housing price elasticity for each expenditure quintile over time. The expenditure quintiles are calculated such that if someone is in the top expenditure quintile, their total expenditure was higher than at least 80 per cent of young households (both owners and renters) in the year they participated in the household survey. This calculation shows that the large decline in compensated housing own-price elasticity is driven by the lowest and highest expenditure quintile households, although the compensated housing own-price elasticity declined for renters in all expenditure quintiles.

Figure 10



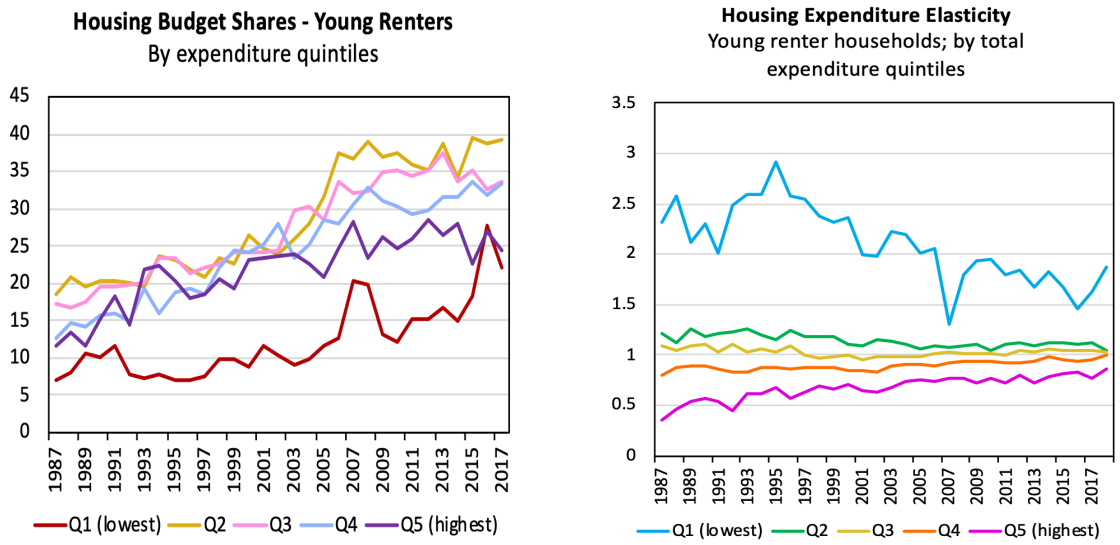
The large decline in compensated own-price housing elasticity of the bottom quintile may be due to the declining share of social housing. While I cannot observe social housing directly in my dataset, it is likely that the majority of young renter households in the lowest expenditure quintile live in social housing. This hypothesis is supported by housing budget shares, which are much lower for the bottom expenditure quintile than the rest of the sample of renters. The decline in the share of young renters living in social housing over the sample period may explain the decline in own-price housing elasticity of this group. In England, social housing tenure peaked in 1979 at 31 per cent of households, and by 2016–2017 it had declined to 17 per cent (Tunstall and Pleace, 2018). The age mix in social housing is very similar to the national average, and it is tightly targeted to people with low incomes. While social rents are calculated using a formula that considers local earning levels and the relative value and features of the property, they are on average only around 50-60 per cent of the market rate (Adam et al., 2015). Therefore, as people move out of social housing and face higher private-sector rents that are more responsive to national housing market conditions, they are more likely to exhibit consumption behaviour consistent with more negative

own-price elasticities.

The elasticity estimates of households in quintiles two and three decline from around -0.15 to -0.2 over the sample period. This group also experienced large falls in homeownership and have the largest housing budget shares in the sample. These estimates suggest that, over the sample period, the median young renter became more sensitive to house price increases and reduced their housing consumption by a larger amount in response. However, housing expenditure elasticity for this group remained stable over this period, but there was a large increase in the housing budget share, from 18 to over 35 per cent of total expenditure. One possible explanation for these results, is that this group were not able to reduce their consumption of housing as much as they wished to as prices rose, placing them under increased financial pressure. As a result, they reduced their consumption of other goods such as leisure by more, causing the budget share of housing to rise.

A declining but positive own-price housing elasticity of the highest expenditure quintile suggests that the highest-spending young households responded to an increase in house prices by increasing their housing expenditure. The very high elasticity estimates observed in the first five years of the sample may also just reflect a small sample size for these years. Since the homeownership rate of this quintile declined by almost 20 percentage points over the sample period, these elasticity estimates are consistent with this group spending more on housing rather than saving for a deposit. In addition, the housing expenditure elasticity of this quintile increased over the sample period, suggesting that over time these households allocated more of any total expenditure increase to housing consumption, which wasn't observed for households in lower expenditure quintiles.

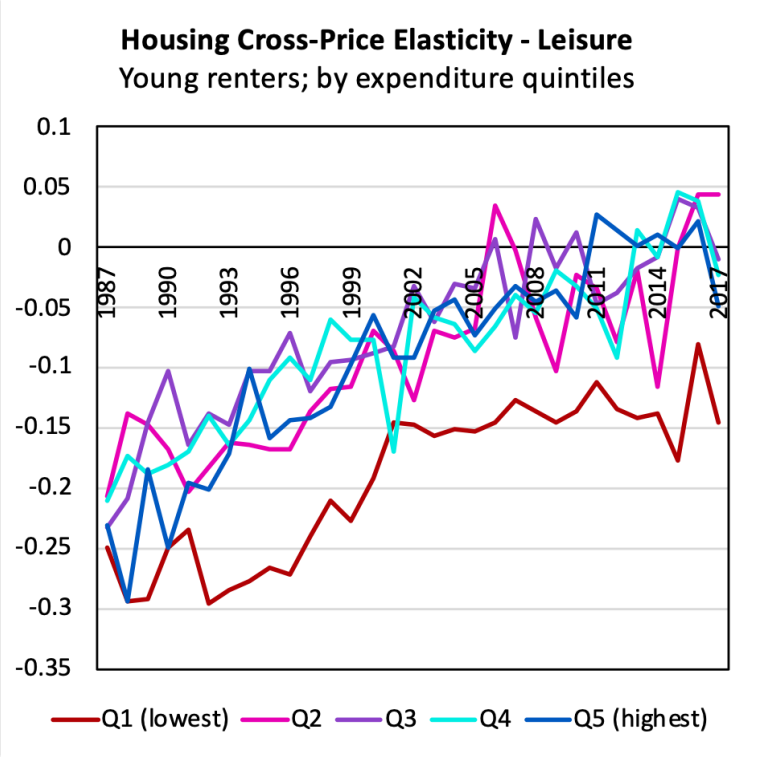
Figure 11



6.3.2 Leisure

The housing cross-price elasticity of demand for leisure sharply increased for young renters over the sample period. In 1987, I estimate that the median young renter would decrease their leisure consumption by 0.25 per cent in response to a 1 per cent increase in house prices. By the end of the sample period, the cross-price elasticity increased to around zero, indicating that the leisure demanded by young renters would not respond to changes in house prices. This trend is broad-based by expenditure quintile. The expenditure elasticity of leisure for renters also increased over this period. Therefore, the leisure consumption of the median renter has become less responsive to house price changes but more responsive to total expenditure or income changes. This result is consistent with households responding to higher house prices by delaying saving up for a mortgage, and instead increasing their expenditure on luxuries such as entertainment and holidays. However, if this were the case, I would expect larger differences in housing cross-price elasticity between expenditure quintiles.

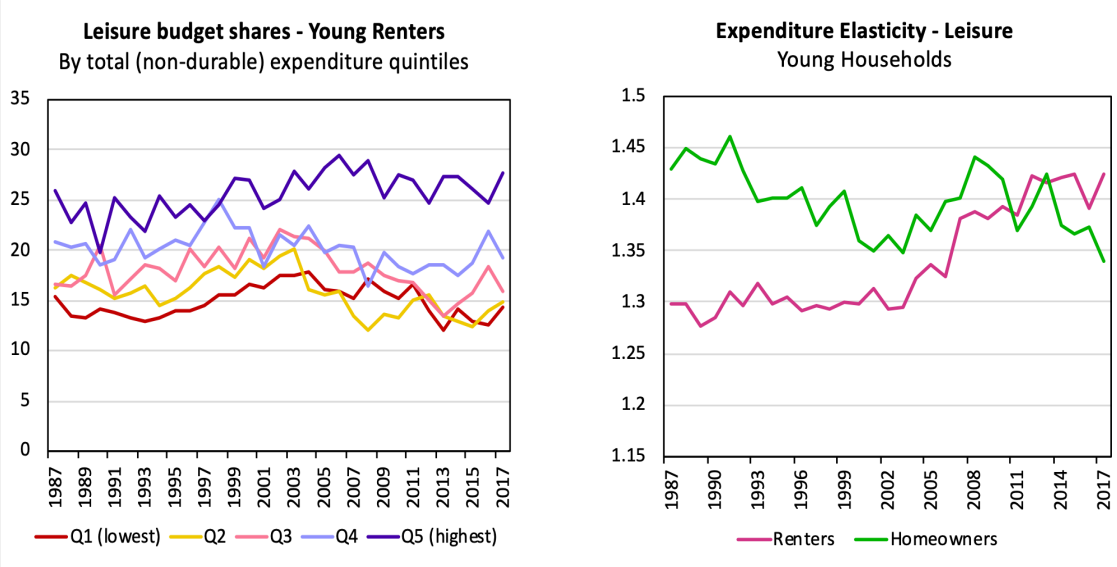
Figure 12



While the housing cross-price elasticities and expenditure elasticities for leisure are quite similar between expenditure quintiles, there has been a large divergence in leisure budget shares. In my demand system, leisure is an amalgamation of two consumption categories: leisure goods and leisure services.[5] There has been a broad-based decline in the budget share of leisure goods for young renters from 6 to 3 per cent. However, young renters in the top expenditure quintile increased their leisure services budget share from 10 to 17 per cent, while, on average, households in the over four expenditure quintiles increased their leisure services budget share by only one percentage point, from around 6 to 7 per cent. Households in the top expenditure quintile allocate a far higher share of their budget to holidays, entertainment and recreation than other expenditure cohorts, and this gap has widened over time.

[5]The main categories of leisure goods are: TV/video/audio equipment, sports, camping and outdoor goods and equipment, newspapers, magazines, books, stationery, and toys, hobbies and photography. The main categories of leisure services are: entertainments, social events, sport, TV and video licence, rental, subscriptions, education and training, hotels and holiday expenses, betting stakes and betting winnings.

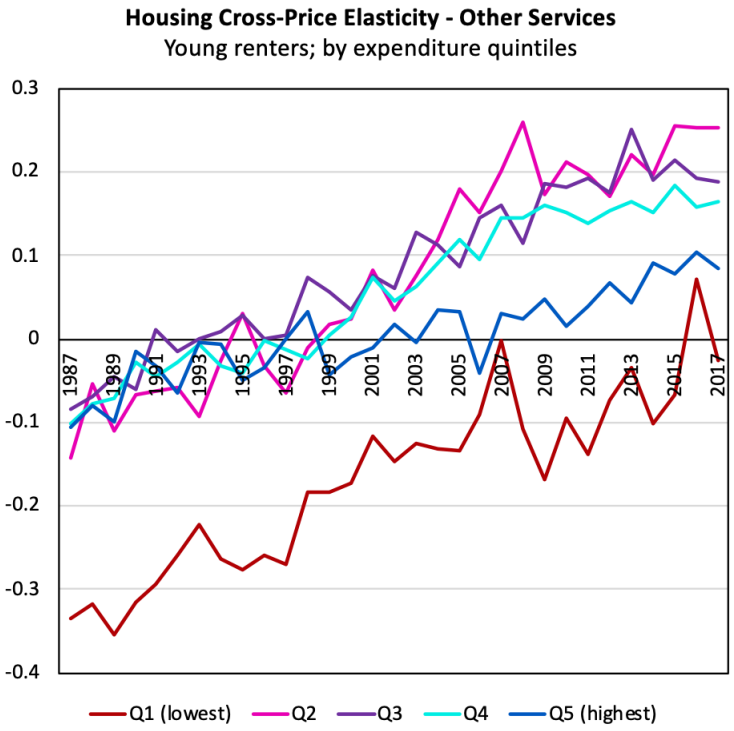
Figure 13



6.3.3 Transport and other services

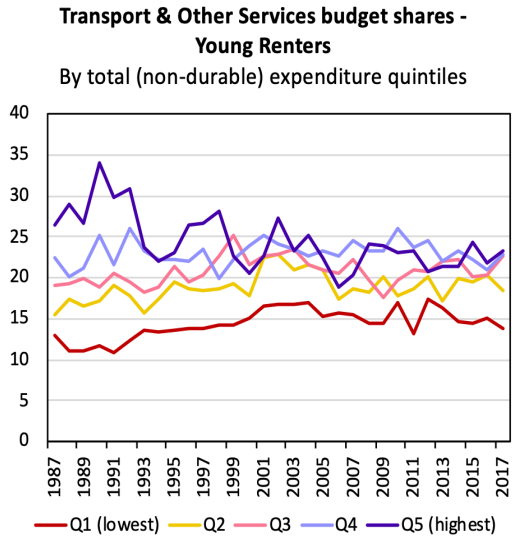
The housing cross-price elasticity of demand for transport & other services was around zero for the first decade of the sample, with the exception of the elasticity of households in the lowest expenditure quintile, likely reflecting social housing trends. The housing cross-price elasticity then sharply increased for households in the middle three expenditure quintiles, but only increased a little for the top expenditure quintile. Therefore, over the sample period, the median-expenditure young renter household increasingly responded to higher house prices by increasing their expenditure on transport and other services, but the demand response of households in the top expenditure quintile has been much more modest. Transport and other services expenditure elasticity declined a little over the sample period, although it remained a luxury good.

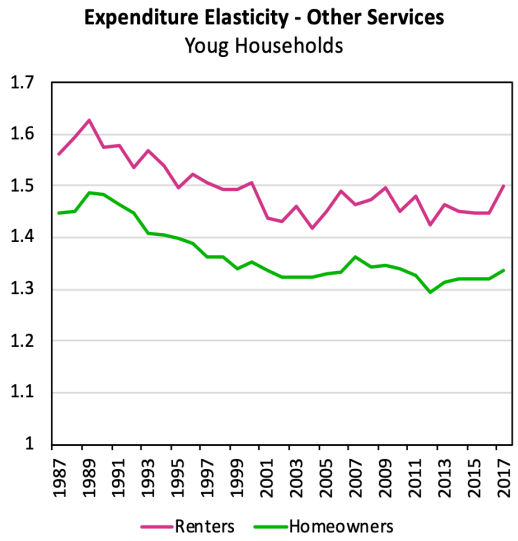
Figure 14



Around 60 per cent of the 'transport & other services' category is made up of motoring expenditure, with transport fares making up an additional 15 per cent. The budget share of motoring declined by 4 percentage points for households in the top expenditure quintile over the sample period, but remained constant for all other quintiles. Therefore, a possible explanation for these households having a much lower housing cross-price elasticity for transport and other services, is that high-income renters are most able to afford living in inner city areas near their workplace and high-quality public transport. For example, 25 per cent of this group live in London, compared to 12 per cent of the overall sample of young households. As housing and rental prices rise, lower-income households seeking more affordable rents move further away from these expensive inner-city areas, and therefore retain their need for a car and spend more on transport.

Figure 15





6.4 Alternate model specifications

I conclude this chapter by estimating alternate specifications of my baseline QUAIDS model and comparing the resultant elasticity estimates to those from my baseline model. I relax the imposition of homogeneity and symmetry and estimate an unrestricted QUAIDS model. I then estimate a QUAIDS model using household income as an instrumental variable for total expenditure to account for potential endogeneity. In both cases, I conclude that while the alternate specifications cause some differences in elasticity estimates, the results from my baseline model are broadly robust to these alternate model specifications.

6.4.1 Homogeneity and symmetry

I impose homogeneity and symmetry upon my baseline QUAIDS model. To assess the implications of these restrictions, I estimate an unrestricted QUAIDS model and then perform Likelihood-Ratio tests to test for homogeneity and symmetry. Unfortunately, both homogeneity and symmetry are strongly rejected in both the full sample and young adult sample. Since the homogeneity restriction $\sum_i \gamma_{ij} = 0 \; \forall i$ is applied to each individual demand equation in my system, I also test each equation for homogeneity. I find that no equation satisfies homogeneity in the full sample, but I fail to

reject the null hypothesis of homogeneity ($p = 0.05$) for the food and leisure budget share equations. In addition, with a stricter p-value of 0.01, I also fail to reject the null of homogeneity for fuel and light.

Table 10: Likelihood-Ratio Tests for Homogeneity & Symmetry

Test for	**Sample**		**df**	χ^2 **estimate**	**P-value**	**Outcome***
Homogeneity	full		5	276.48	0.000	Reject
		Food	1	19.27	0.000	Reject
		House	1	131.27	0.000	Reject
		Fuel	1	26.12	0.000	Reject
		Leisure	1	65.51	0.000	Reject
		Other goods	1	85.88	0.000	Reject
		Other services	1	45.62	0.000	Reject
Homogeneity	young		5	124.61	0.000	Reject
		Food	1	0.6	0.438	Fail to reject
		House	1	27.7	0.000	Reject
		Fuel	1	5.02	0.025	Reject
		Leisure	1	1.77	0.184	Fail to reject
		Other goods	1	104.91	0.000	Reject
		Other services	1	30.68	0.000	Reject
Symmetry	full		10	11856.18	0.000	Reject
Symmetry	young		10	2247.80	0.000	Reject

* Null hypothesis rejected if p<0.05

In practise, specification tests for homogeneity and symmetry of estimated demand systems regularly fail (Keuzenkamp and Barten, 1995). Anderson and Blundell (1982) attribute these failures to, among other factors, inadequately incorporating dynamic elements such as adjustment costs. They argue that homogeneity and symmetry should only be imposed on the long-run structure of the system, as short-run behaviour is more likely to deviate from utility theory. The implications of rejecting homogeneity and symmetry are unclear; a rejection could occur because the test statistics applied may not be valid, or that the demand system estimated is a poor approximation of the real demand relationships, or that the ideal demand equations are, in reality, not homogeneous or symmetrical.

To assess the practical consequences of imposing homogeneity and symmetry, I

compare the income and compensated price elasticities calculated using a QUAIDS model estimated without imposing homogeneity and symmetry, and a model estimated with those restrictions. In both cases these models are estimated using the sample of young households. I report the results in *Table 10* and *Table 11*

Table 11: Mean Income & Compensated Price Elasticity Estimates - Unrestricted vs Homogeneity Imposed
Young Households

	Food		Housing		Fuel		Leisure		Other Goods		Other Services	
	UN	HOM	UN	HOM	UN	HOM	UN	HOM	UN	HOM	UN	HOM
Income	0.348*	0.348*	0.995*	0.997*	0.040*	0.039*	1.353*	1.352*	0.975*	0.969*	1.374*	1.377*
Food price	-0.743*	-0.687*	0.21	-0.217*	0.617*	0.877*	-0.352*	-0.21	0.017	1.089*	0.344*	-0.195
Housing price	0.157*	0.159*	-0.211*	-0.230*	-0.066	-0.056	0.074	0.08	0.052	0.102*	0.073	0.049
Fuel price	0.137*	0.128*	0.406*	0.481*	-0.512*	-0.557*	-0.139*	-0.164*	-0.209*	-0.399*	-0.182*	-0.087*
Leisure price	0.398*	0.376*	-0.165	0.001	0.164	0.063	-0.358*	-0.413*	-1.169*	-1.586*	1.135*	1.345*
Other goods price	0.148	0.141	0.544*	0.610*	-0.042	-0.079	-0.348*	-0.370*	-0.879*	-1.051*	0.232	0.318*
Other services price	-0.122	-0.117	-0.587*	-0.646*	-0.278	-0.247	1.057*	1.077*	1.695*	1.845*	-1.355*	-1.430*

'UN' = 'unrestricted estimates', 'HOM' = 'homogeneity imposed'. * = significant at p=0.05; standard errors omitted

Table 12: Mean Income & Compensated Price Elasticity Estimates - Homogeneity vs Symmetry Imposed
Young Households

	Food		Housing		Fuel		Leisure		Other Goods		Other Services	
	HOM	SYM	HOM	SYM	HOM	SYM	HOM	SYM	HOM	SYM	HOM	SYM
Income	0.348*	0.395*	0.997*	0.985*	0.039*	0.237*	1.352*	1.350*	0.969*	0.959*	1.377*	1.381*
Food price	-0.687*	-0.945*	-0.217*	0.318*	0.877*	0.537*	-0.210	-0.010	1.089*	0.570*	-0.195	-0.321*
Housing price	0.159*	0.527*	-0.230*	-0.679*	-0.056	1.033*	0.080	0.125*	0.102*	0.030	0.049	-0.029
Fuel price	0.128*	0.232*	0.481*	0.269*	-0.557*	-0.475*	-0.164*	-0.132*	-0.399*	-0.217*	-0.087*	-0.034
Leisure price	0.376*	-0.012	0.001	0.097	0.063	-0.391*	-0.413*	-0.141	-1.586*	-1.272*	1.345*	1.153*
Other goods price	0.141	0.671*	0.610*	0.022	-0.079	-0.589*	-0.370*	-1.171*	-1.051*	-0.473*	0.318*	1.088*
Other services price	-0.117	-0.474*	-0.646*	-0.026	-0.247	-0.115	1.077*	1.329*	1.845*	1.361*	-1.430*	-1.856*

'HOM' = 'homogeneity imposed', 'SYM' = 'symmetry (and therefore also homogeneity) imposed. * = significant at p=0.05; standard errors omitted

The homogeneity restriction has very little impact on the mean point estimates of income and compensated own-price elasticities. It has a larger impact on a few of the cross-price elasticities for leisure, other goods and other services, but in general, the consequences of imposing homogeneity are small.

The imposition of symmetry has a larger impact on the elasticity point estimates. It has little impact on income elasticities with the exception of fuel, which is a little larger when symmetry is imposed. The compensated own-price elasticities for food, housing and other services are a little more negative when symmetry is imposed, the compensated own-price elasticity for other goods is a little less negative, while the compensated own-price elasticity for leisure becomes insignificant when symmetry is imposed, although the sign remains negative. Focusing on the cross housing-price elasticities of demand, imposing symmetry increases the magnitude of the elasticity for food, housing, fuel and leisure, while the coefficients on other goods and services are not significant. I conclude that the imposition of symmetry may have a material impact on some of my estimates and I acknowledge this as a potential limitation of my modelling approach.

6.4.2 Endogeneity

A classic issue with estimating almost ideal demand systems, is that total expenditure is both a right-hand-side explanatory variable, and the denominator of the budget share (dependent) variable. As a result, there is a risk of endogeneity where one or more explanatory variables is correlated with the error term, leading to biased and inconsistent estimates. For example, a common shock could determine both the allocation of expenditure between expenditure categories, and the total level of expenditure. Even if true expenditure is exogenous, endogeneity can also be introduced if total expenditure is measured with error. Tests for homogeneity are equivalent to a test for endogenous expenditure assuming homogeneity (Attfield, 1985). The failure of homogeneity therefore potentially suggests the presence of endogeneity. To address this issue, I follow (Banks, Blundell and Lewbel, 1997), and use the Two-Stage Least Squares (2SLS) estimator, with the expenditure and expenditure^2 terms being instrumented with disposable household income and its square.

Household income is a commonly used instrumental variable for expenditure in the demand literature. As household income will be highly correlated with expendi-

ture, the requirement for instrument informativeness is easily met. If the potential endogeneity is caused by measurement error, then household income is a valid instrumental variable if any error in measuring these two variables is independent. If the potential endogeneity is due to heterogeneity in tastes, then income is a valid instrument if labour supply is weakly separable from consumption (Attanasio and Lechene, 2014). The validity of this second assumption is unclear, although there is evidence that labour supply is independent of the response of renters to higher house prices Disney and Gathergood (2018).

Following the standard 2SLS estimation procedure, I firstly regress total expenditure against the two instrumental variables and exogenous regressors, and then insert the fitted values from this first stage regression into my QUAIDS model in lieu of total expenditure and its square variables. I report the regression output from the first and second stage of the regression in *Appendix 9.7.* I report in *Table 13* a comparison of the mean income and compensated price elasticity estimates estimated using the baseline QUAIDS model, and the QUAIDS model estimated with instrumental variables. In general, the differences in elasticity point estimates are small, and I conclude that endogeneity is not a significant concern.

Table 13: Mean Income & Compensated Price Elasticity Estimates - Baseline vs Instrumental Variables - Young Households

	Food		Housing		Fuel		Leisure		Other Goods		Other Services	
	BL	IV	BL	IV	BL	IV	BL	IV	BL	IV	BL	IV
Income	0.393*	0.413*	0.985*	1.140*	0.244*	0.259*	1.343*	1.296*	0.961*	0.815*	1.379*	1.350*
Food price	-0.910*	-0.834*	0.315*	0.339*	0.531*	0.553*	-0.019	-0.061	0.531*	0.457*	-0.303*	-0.289*
Housing price	0.523*	0.555*	-0.613*	-0.837*	1.016*	1.060*	0.09	0.116*	-0.025	0.148*	-0.019	0.023
Fuel price	0.228*	0.237*	0.262*	0.277*	-0.475*	-0.432*	-0.128*	-0.138*	-0.198*	-0.214*	-0.039	-0.048
Leisure price	-0.025	-0.079	0.070	0.091	-0.387*	-0.415*	-0.088	-0.099	-1.269*	-1.181*	1.152*	1.120*
Other goods price	0.631*	0.548*	-0.018	0.108	-0.551*	-0.600*	-1.171*	-1.098*	-0.342*	-0.460*	1.052*	1.018*
Other services price	-0.446*	-0.427*	-0.017	0.021	-0.136	-0.166	1.317*	1.279*	1.303*	1.251*	-1.842*	-1.824*

'BL' = 'baseline model', 'IV' = 'model with instrumental variables'; *=significant at p=0.05; standard errors omitted. The baseline estimates reported in this table are a little different to those reported with my baseline model in Chapter 6.3 of this thesis. This is because I am not able to match all households with disposable household income data, and so this regression is estimated with a reduced sample.

7 Welfare Analysis

The previous chapter investigated how young renters changed their allocation of consumption between different expenditure categories in response to house price changes. I identified differences in this allocation over time, and between renter households on different parts of the income distribution, proxied by total expenditure quintiles. In this chapter, I aggregate these differences into an overall estimate of the welfare consequences of price changes for each household in my sample.

As demonstrated in chapter five of this thesis, house price growth is associated with consumption growth due to common factors such as income expectations. The decline in homeownership was during a period of strong income growth for young renter and homeowner households. Therefore, I find that while housing became more expensive relative to disposable household income, the overall purchasing power of young people improved as other goods and services became cheaper. However, since the Great Recession, welfare has stagnated at a level below its pre-2008 peak.

7.1 Methodology

To estimate the welfare consequences of price changes (including house prices) on young households between 1987-2017, I calculate the compensating variation (CV) of these price changes. Compensating variation is the amount of additional money a household would need to return to their original utility following a change in prices at $t = 1$, keeping total expenditure w otherwise fixed in two periods ($t = 0, 1$)

$$CV = e(p_1, u_1) - e(p_1, u_0) = w - e(p_1, u_0)$$

Since utility is directly unobservable, compensating variation is calculated by approximation. I follow the approach of Friedman and Levinsohn (2001), and take a second-order Taylor expansion of the expenditure function $e(p, u)$ with respect to price. A full derivation is provided in *Appendix 9.7*. This results in the following expression for compensating variation:

$$CV \approx \sum_{i=1}^{n} w_i \Delta \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \varepsilon_{ij} \Delta \ln p_i \Delta \ln p_j$$

where w_i is the budget share of commodity i (out of n different commodities) in the initial period before the price change, $\Delta \ln p_i$ is the change in price of good i and ε_{ij} is the compensated price elasticity of good i with respect to the price change of good j that I obtain from my QUAIDS model. The first term of this expression can be interpreted as the income effects of a price change, while the second term represents the substitution effects. In general, price increases of goods that are more inelastic will generate larger compensating variation estimates, as households are less willing or able to substitute to other relatively cheaper goods. Since this calculation assumes total expenditure (and income) is constant between the two periods, I deflate prices by the disposable household income of young households in my sample. Therefore, compensating variation will be positive if prices grow faster than nominal household income growth.

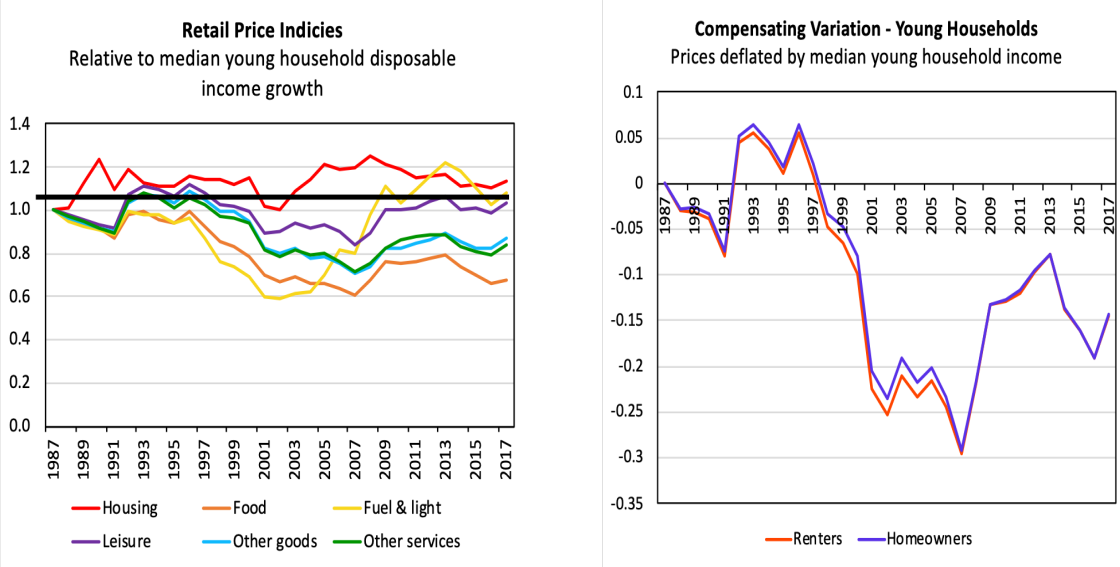
I calculate the compensating variation for the price changes that occur each year of my sample, relative to the base year of 1987. Since my dataset is cross-sectional rather than a panel, to obtain w_i, which are budget shares in 1987, I match post-1987 households to the budget allocation choices of an average 1987 household based on region, age and tenure choice. For example, I match a 27 year old renter living in Yorkshire and the Humber with the average budget shares of all 27 year old renters living in Yorkshire and the Humber in 1987.

I calculate two sets of compensating variation estimates. Firstly, I deflate the retail price indices for the six commodities in my QUAIDS model by the median young household disposable income growth in my sample. Therefore, all households face the same price growth relative to income. Secondly, to incorporate differences in income growth among renters and homeowners, I calculate the compensating variation for young renter and homeowner households in each expenditure quintile. I deflate the prices faced by households in each quintile by the median household income growth of renters or homeowners in that quintile. The expenditure quintiles are calculated based on all young people to control for the compositional shift towards more higher-income renters.

7.2 Results

I firstly report the results when I deflate prices by the same income growth index for all households in my sample. Relative to median income growth for young households in my sample, housing is the only expenditure category that has grown consistently at faster pace than income. As a result, compensating variation is negative for the majority of the sample period, with the exception of 1992–1998, when the compensating variation became positive reflecting the recession of 1991–92 and subsequent years of high unemployment and low median household income growth relative to retail price inflation. Since 1998, the median young household is better off relative to 1987 as the increase in housing prices over this period was more than offset by declines in the price of other goods and services relative to income growth.

Figure 16

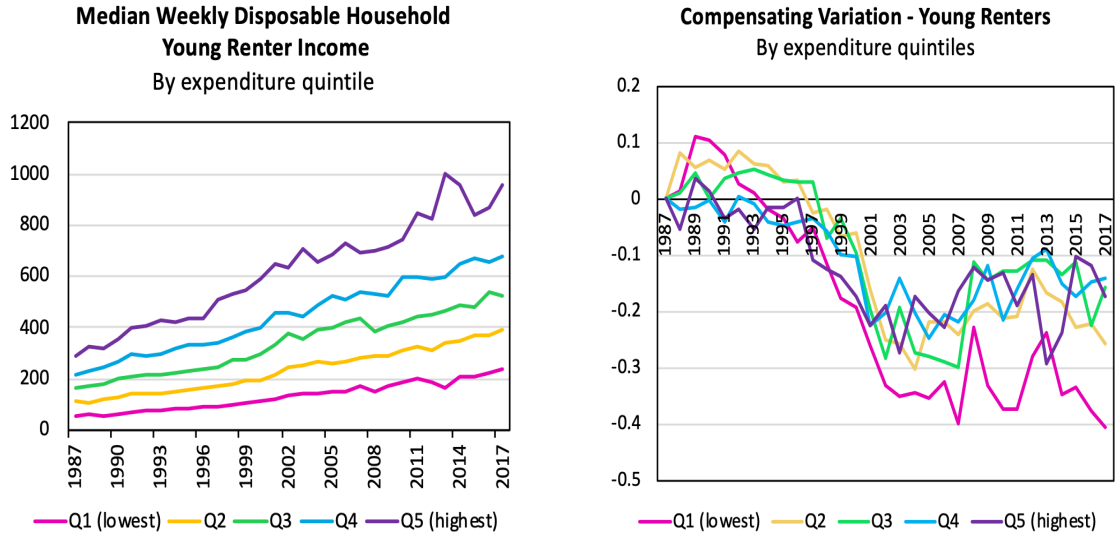


The compensating variation for homeowners and renters is very similar, as differences in price elasticities and budget allocation between goods with relatively faster and slower price growth broadly offset. For example, while renters allocated a higher share of their budget to housing relative to homeowners, this was offset by renters allocating more of their budget to food and less to leisure than homeowners. Housing grew faster than other goods, but food prices grew more slowly than all other goods in my demand system. Since I deflated prices by the same median disposable income series for both young renters and homeowners, this compensating variation calcula-

tion assumes identical income growth for renters and homeowners. However, in my sample, disposable income grew faster for the median young renter relative to the median homeowner (312 and 236 per cent respectively over the sample period). This is partially due to an increase in higher-income young households remaining renters rather than transitioning to homeownership.

To take these differences in income growth into account, I calculate the compensating variation for young renters and homeowners using expenditure-quintile-specific income indices to deflate prices. For young renters, in the first half of the sample, compensating variation was a little higher for quintiles two and three relative to the higher quintiles, but from the early 2000s, the compensating variation for the 60 per cent of the sample with the highest expenditure is very similar, and higher than the rest of the sample. The more negative compensating variation for the bottom quintile is mostly due to their much smaller housing budget share (possibly due to social housing) and larger food budget share.

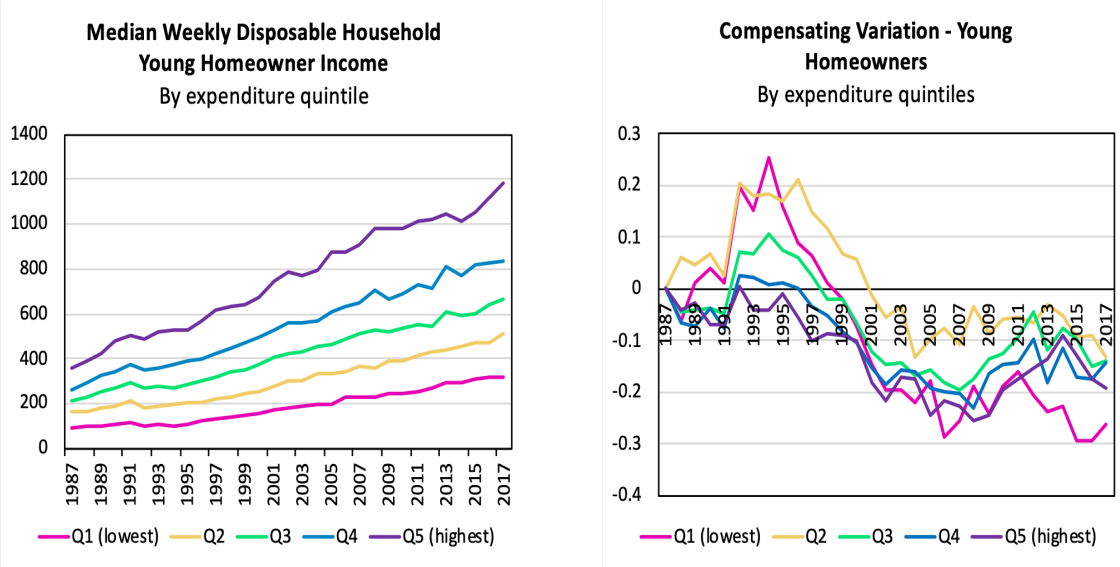
Figure 17



Homeowner households in higher expenditure quintiles consistently have lower compensating variation than households in lower expenditure quintiles. This is the opposite result to renter households, for whom higher expenditure quintiles have higher compensating variation. This mostly reflects the much larger variance in housing budget shares between homeowners relative to renters in different expenditure quintiles.

A higher housing budget share results in a higher compensating variation estimate due to the magnitude of housing price growth. The sample size used to calculate the compensating variation for the lowest homeowner expenditure quintile is too small to draw meaningful conclusions from as most low-expenditure households are not homeowners.

Figure 18

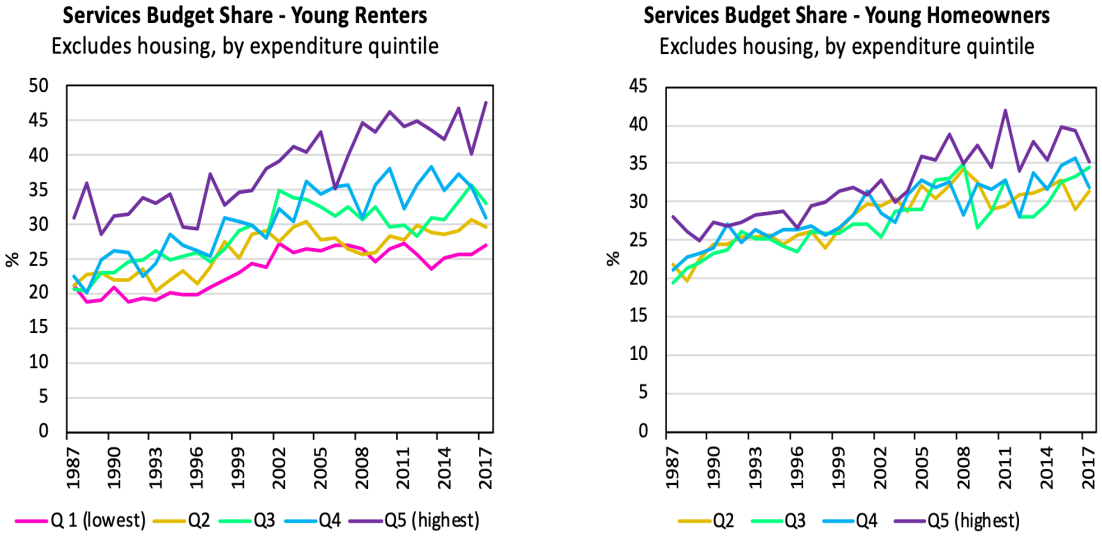


I conclude that the decline in homeownership rates of young people between the early 1990s and the Great Recession is associated with an increase in welfare of young people as measured using compensating variation. This is because household income growth was robust over this period, therefore the purchasing power of households over non-housing goods and services increased, offsetting the negative welfare consequences of high house price growth. However, compensating variation has remained fairly stable following the Great Recession at a higher level than the early-to-mid 2000s. This indicates that the average welfare of young households has declined relative to its pre-2008 peak. This decline has been broad based by income and tenure, and can be attributed to various factors, including weak income growth and a re-allocation of expenditure towards housing and services consumption. The share of non-housing expenditure allocated to services has increased by over ten percentage points for both renters and homeowners, with a concomitant decline in goods expenditure[6], Services

[6]Services are catering, household services, leisure services and fares and other travel costs. I exclude quintile one from the homeowner chart due to volatility of the series.

inflation is consistently higher than goods inflation due to a higher wage component in pricing and slower productivity improvements (Ferrara, 2019).

Figure 19



8 Conclusion

This thesis set out to answer two questions: how does the aggregate quantity of consumption by young renters respond to house price shocks, and how has the increase in UK house prices changed how young renters allocate consumption between major expenditure categories. I find that there is a positive relationship between house price and non-housing consumption growth by young renters, but conclude that this is mostly due to a common factor such as income expectations independently determining both variables. This result is robust to significant changes in homeownership rates, although I find some evidence of an asymmetrical response to house price up-swings and down-swings. In addressing my second question, I observe large heterogeneities in how the demand by relatively higher- and lower-spending households for different goods and services responded to house price shocks over the sample period. Social housing remains an important determinant of spending patterns for low-income households. I find some evidence of increasing financial stress among lower-expenditure young renter households, alongside increasing expenditure on luxury goods such as entertainment and holidays by higher-expenditure rental households. However, both these household types significantly increased the share of their budgets allocated to housing over the sample period, and experienced large declines in homeownership rates. These results highlight the importance of tailored housing affordability policies that consider these heterogeneities.

Further research should consider alternate margins of adjustment available to young renters in response to house price shocks, such as changes to labour supply or regional migration, and how these additional choices interact with consumption and tenure choices. In addition, there are a couple of limitations of these results that could be addressed in future research. The most significant of these is that I only had access to national retail price indices, therefore I could not incorporate regional price variation in my demand system analysis. Having estimates of imputed rent for young homeowners would have also improved my ability to compare the consumption responses of renters and homeowners. Despite these data limitations, the two motivating questions of this thesis are able to be successfully addressed, thereby potentially contributing to designing better housing affordability policies.

References

Adam, Stuart, Daniel Chandler, Andrew Hood, and Robert Joyce. 2015. "Social housing in England: a survey." Institute for Fiscal Studies Briefing Note BN178.

Aladangady, Aditya. 2017. "Housing Wealth and Consumption: Evidence from Geographically Linked Microdata." *American Economic Review*, 107(11): 3415–46.

Anderson, G J, and R W Blundell. 1982. "Estimation and Hypothesis Testing in Dynamic Singular Equation Systems." *Econometrica*, 50(6): 1559–1571.

Artle, Roland, and Pravin Varaiya. 1978. "Life cycle consumption and homeownership." *Journal of Economic Theory*, 18(1): 38–58.

Aruoba, S. Boragan, Ronel Elul, and Sebnem Kalemli-Ozcan. 2019. "How Big is the Wealth Effect? Decomposing the Response of Consumption to House Prices." Federal Reserve Bank of Philadelphia Working Papers 19-6.

Attanasio, Orazio, and Valérie Lechene. 2014. "Efficient Responses to Targeted Cash Transfers." *Journal of Political Economy*, 122(1): 178 – 222.

Attanasio, Orazio P., Laura Blow, Robert Hamilton, and Andrew Leicester. 2009. "Booms and Busts: Consumption, House Prices and Expectations." *Economica*, 76(301): 20–50.

Attanasio, Orazio P., Renata Bottazzi, Hamish W. Low, Lars Nesheim, and Matthew Wakefield. 2012. "Modelling the demand for housing over the life cycle." *Review of Economic Dynamics*, 15(1): 1 – 18.

Attfield, Clifford L. F. 1985. "Homogeneity and endogeneity in systems of demand equations." *Journal of Econometrics*, 27(2): 197–209.

Banks, James, Richard Blundell, and Arthur Lewbel. 1997. "Quadratic Engel Curves And Consumer Demand." *The Review of Economics and Statistics*, 79(4): 527–539.

Berger, David, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra. 2017. "House Prices and Consumer Spending." *The Review of Economic Studies*, 85(3): 1502–1542.

Blanciforti, Laura Ann, Richard D. Green, and Gordon A. King. 1986. *U.S. Consumer Behavior over the Postwar Period: An Almost Ideal Demand System Analysis. Monographs*, University of California, Davis, Giannini Foundation.

Blow, Laura. 2003. "Demographics in Demand Systems." Institute for Fiscal Studies Report 03/18.

Blundell, Richard, and Jean Marc Robin. 1999. "Estimation in Large and Disaggregated Demand Systems: An Estimator for Conditionally Linear Systems." *Journal of Applied Econometrics*, 14(3): 209–232.

Bottazzi, Renata, Thomas Crossley, and Matthew Wakefield. 2012. "Late starters or excluded generations? A cohort analysis of catch up in home ownership in England." Institute for Fiscal Studies Working Papers W12/10.

Browning, Martin, Angus Deaton, and Margaret Irish. 1985. "A Profitable Approach to Labor Supply and Commodity Demands over the Life-Cycle." *Econometrica*, 53(3): 503–543.

Campbell, John Y., and Joao F. Cocco. 2007. "How do house prices affect consumption? Evidence from micro data." *Journal of Monetary Economics*, 54(3): 591–621.

Chetty, Raj, and Adam Szeidl. 2016. "Consumption Commitments and Habit Formation." *Econometrica*, 84: 855–890.

Cribb, Jonathan, and Polly Simpson. 2018. "Barriers to homeownership for young adults." Institute for Fiscal Studies Book chapter 13475.

Cristini, Annalisa, and Almudena Sevilla. 2014. "Do House Prices Affect Consumption? A Re-assessment of the Wealth Hypothesis." *Economica*, 81(324): 601–625.

Crossley, Thomas F., Peter Levell, and Hamish Low. 2020. "House Price Rises and Borrowing to Invest." Institute for Fiscal Studies Working Paper 20 2.

Deaton, Angus. 1985. "Panel data from time series of cross-sections." *Journal of Econometrics*, 30(1-2): 109–126.

Deaton, Angus, and John Muellbauer. 1980*a*. "An Almost Ideal Demand System." *The American Economic Review*, 70(3): 312–326.

Deaton, Angus, and John Muellbauer. 1980*b*. *Economics and Consumer Behavior*. Cambridge University Press.

Disney, Richard, and John Gathergood. 2018. "House Prices, Wealth Effects and Labour Supply." *Economica*, 85(339): 449–478.

Engelhardt, Gary V. 1994. "House Prices and the Decision to Save for Down Payments." *Journal of Urban Economics*, 36(2): 209 – 237.

Ferrara, Luigi. 2019. "What is behind the change in the gap between services price inflation and goods price inflation?" European Central Bank Economic Bulletin 5.

Friedman, Jed, and James Levinsohn. 2001. "The Distributional Impacts of Indonesia's Financial Crisis on Household Welfare: A "Rapid Response" Methodology." National Bureau of Economic Research Working Paper P8564.

Hall, Robert E. 1978. "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence." *Journal of Political Economy*, 86(6): 971–987.

Head, Allen, and Huw Lloyd-Ellis. 2012. "Housing Liquidity, Mobility, and the Labour Market." *The Review of Economic Studies*, 79(4): 1559–1589.

Henningsen, Arne. 2015. "Demand Analysis with the "Almost Ideal Demand System" in R: Package micEconAids ." mimeo, available at CRAN Repository.

Joyce, Robert, Matthew Mitchell, and Agnes Norris Keiller. 2017. "The cost of housing for low-income renters." Institute for Fiscal Studies Report .

Judge, Louise. 2019. "Moving matters: Housing costs and labour market mobility." Resolution Foundation Briefing.

Keuzenkamp, Hugo A., and Anton P. Barten. 1995. "Rejection without falsification on the history of testing the homogeneity condition in the theory of consumer demand." *Journal of Econometrics*, 67(1): 103 – 127.

Khorunzhina, Natalia. 2020. "Intratemporal nonseparability between housing and nondurable consumption: evidence from reinvestment in housing stock." *Journal of Monetary Economics*.

Lee, Lung-Fei, and Mark Pitt. 1986. "Microeconometric Demand Systems with Binding Nonnegativity Constraints: The Dual Approach." *Econometrica*, 54(5): 1237–42.

Li, Wenli, and Rui Yao. 2007. "The Life-Cycle Effects of House Price Changes." *Journal of Money, Credit and Banking*, 39(6): 1375–1409.

Li, Wenli, Haiyong Liu, Fang Yang, and Rui Yao. 2016. "Housing over time and over the life cycle: a structural estimation." *International Economic Review*, 57(4): 1237–1260.

Mian, Atif, Kamalesh Rao, and Amir Sufi. 2013. "Household Balance Sheets, Consumption, and the Economic Slump." *The Quarterly Journal of Economics*, 128(4): 1687–1726.

Miles, David, and Victoria Monro. 2019. "UK house prices and three decades of decline in the risk-free real interest rate." Bank of England Staff Working Paper 837.

Muellbauer, John. 2018. "Housing, Debt and the Economy: a Tale of Two Countries." University of Oxford Department of Economics Discussion Paper Series 855.

Noriko Amano-Patiño. 2019. "Nutritional Inequality: The Role of Prices, Income, and Preferences." *Cambridge Working Papers in Economics*, 1909.

OECD. 2019. *Under Pressure: The Squeezed Middle Class.* Paris:OECD Publishing.

Oldfield, Z., J. Banks, P. Levell, and A. Leicester. 2019. "Family Expenditure Survey and Living Costs and Food Survey Derived Variables, 1968-2017." [data collection].UK Data Service. SN: 8583.

Parsons, George R. 1986. "An Almost Ideal Demand System for Housing Attributes." *Southern Economic Journal*, 53(2): 347–363.

Poi, Brian P. 2012. "Easy demand-system estimation with quaids." *Stata Journal*, 12(3): 433–446.

Ray, Ranjan. 1983. "Measuring the costs of children: An alternative approach." *Journal of Public Economics*, 22(1): 89–102.

Rios-Rull, Jose-Victor, Greg Kaplan, and Sebastian Dyrda. 2016. "Business Cycles and Household Formation: The Micro vs the Macro Labor Elasticity." Society for Economic Dynamics 2016 Meeting Papers 1347.

Sheiner, Louise. 1995. "Housing Prices and the Savings of Renters." *Journal of Urban Economics*, 38(1): 94 – 125.

Tunstall, Rebecca Katharine, and Nicholas Pleace. 2018. "Social Housing: Evidence Review." University of York Research Report.

Udagawa, Chihiro, and Paul Sanderson. 2017. "The impacts of family support on access to homeownership for young people in the UK." UK Social Mobility Commission Report.

West, Sarah E., and Roberton C. Williams. 2007. "Optimal taxation and cross-price effects on labor supply: Estimates of the optimal gas tax." *Journal of Public Economics*, 91(3): 593 – 617.

Yoshikawa, Hiroshi, and Fumio Ohtaka. 1989. "An analysis of female labor supply, housing demand and the saving rate in Japan." *European Economic Review*, 33(5): 997 – 1023.

9 Appendix

9.1 Summary statistics tables

Table 1: Summary Statistics - Full Sample

		Sample average by decade (%)			
Variable	**Outcome**	1978-1987	1988-1997	1998-2007	2008-2017
Tenure					
	Own outright	21.8	24.1	29.1	35.6
	Mortgage	35.6	42.1	40.4	33.1
	Rent	40.4	32.1	29.1	30.2
	Other	2.1	1.7	1.4	1.1
Age					
	<20	0.4	0.4	0.4	0.2
	20-29	13.2	13.2	9.7	7.6
	30-39	20.2	20.0	19.8	15.8
	40-49	16.4	18.3	19.6	19.4
	50-59	16.1	14.7	17.6	18.8
	60-69	16.8	15.2	14.5	18.2
	70-79	12.7	12.6	12.5	13.0
	>79	4.2	5.6	6.0	7.0
No. adults					
	1	26.3	32.3	34.8	33.0
	2	59.7	56.0	54.9	55.8
	3	10.4	9.0	7.9	8.3
	> 3	3.6	2.8	2.5	3.0
No. kids <2					
	0	92.7	92.8	94.2	94.1
	1	7.0	6.9	5.6	5.7
	>1	0.3	0.3	0.2	0.2
No. kids 2-4					
	0	89.8	90.0	91.3	91.7
	1	9.0	8.9	7.8	7.4
	>1	1.3	1.2	0.9	0.9
No. kids 5-18					
	0	69.4	74.3	74.4	77.1
	1	13.9	12.0	12.4	11.7
	2	12.2	10.2	9.7	8.6
	>2	4.6	3.5	3.5	2.6
Education					
	A-levels	18.5	25.8	35.3	41.3
	Degree	7.8	11.0	16.4	22.0
Region					
	North East	6.3	6.1	4.9	4.9
	Yorkshire & the Humber	9.5	9.2	9.0	9.4
	North west & Merseyside	11.6	11.1	11.4	11.5
	East Midlands	7.1	7.3	7.6	8.1
	West Midlands	9.5	9.2	8.9	9.4
	Eastern	3.7	3.9	7.9	10.1
	London	11.4	10.7	10.0	9.0
	South East	18.3	19.2	16.3	13.8
	South West	7.8	8.9	9.6	9.5
	Wales	5.5	5.2	5.3	4.9
	Scotland	9.1	9.2	9.2	9.5
N		69,964	66,789	62,526	50,451

Table 2: Summary Statistics - Young Sample (aged 18-34)

		Sample average by decade (%)			
Variable	**Outcome**	1978-1987	1988-1997	1998-2007	2008-2017
Tenure					
	Own outright	2.3	1.4	2.7	3.2
	Mortgage	54.0	55.7	48.9	37.0
	Rent	41.1	41.1	46.8	58.3
	Other	2.6	1.8	1.7	1.6
Age					
	<20	1.7	1.8	1.9	1.3
	20-24	18.6	18.1	15.9	15.2
	25-29	36.8	37.5	34.2	35.0
	30-34	42.9	42.6	48.0	48.6
No. adults					
	1	22.2	33.9	36.5	31.4
	2	75.1	62.8	59.2	63.6
	3	2.0	2.2	2.7	3.1
	> 3	99.3	1.1	1.6	1.9
No. kids <2					
	0	76.8	78.2	81.3	78.1
	1	22.1	20.9	18.0	21.1
	>1	1.2	1.0	0.7	0.8
No. kids 2-4					
	0	71.0	74.1	76.9	76.1
	1	25.1	22.5	20.4	21.3
	>1	3.9	3.4	2.8	2.7
No. kids 5-18					
	0	67.5	72.8	72.5	75.5
	1	16.7	14.8	16.0	14.6
	2	12.3	9.7	8.5	7.1
	>2	3.6	2.7	3.0	2.8
Education					
	A-levels	31.7	37.4	52.6	70
	Degree	14.4	15.9	26.6	40.7
Region					
	North East	6.0	6.2	4.9	4.9
	Yorkshire & the Humber	9.6	9.5	9.2	10.4
	North west & Merseyside	11.6	11.6	11.6	12.0
	East Midlands	7.3	7.2	7.8	8.4
	West Midlands	9.4	8.9	8.5	9.5
	Eastern	3.4	3.6	7.4	9.4
	London	12.8	12.8	12.3	10.4
	South East	18.3	18.2	15.4	12.3
	South West	7.4	8.5	8.4	8.2
	Wales	4.9	4.5	5.4	4.2
	Scotland	9.3	9.1	9.1	10.3
N		16,632	15,882	12,100	7,675

9.2 Regression output - Life cycle consumption model

I ran this specification four times using different sample periods. I produce the full output below for the regression estimated using the full 1978–2018 sample. The differences in coeffients between sample periods was small.

Table 14: Life-Cycle Consumption Regression Results - House Price Growth

Variable	Coefficient	St. error
constant	0.441*	0.171
age	0.269*	0.019
age^2	-0.010*	0.001
age^3	0.000*	0.000
age^4	0.000*	0.000
age^5	0.000*	0.000
cohort 2	0.173*	0.007
cohort 3	0.271*	0.007
cohort 4	0.388*	0.007
cohort 5	0.476*	0.008
cohort 6	0.520*	0.008
cohort 7	0.555*	0.009
cohort 8	0.568*	0.009
cohort 9	0.567*	0.010
cohort 10	0.608*	0.010
cohort 11	0.663*	0.011
cohort 12	0.688*	0.011
cohort 13	0.679*	0.012
cohort 14	0.628*	0.014
cohort 15	0.568*	0.015
cohort 16	0.520*	0.018
cohort 17	0.381*	0.026
cohort 18	0.362*	0.079
kids age 0-2	-0.016*	0.005
no. adults	0.577*	0.002
kids age 2-5	-0.006	0.004
kids age 5-18	0.092*	0.002
> 2 adults	-0.324*	0.005
A level	0.184*	0.003
degree	0.113*	0.004

* = significant at p=0.05; omits coefficients on occupations and monthly dummies

Yorkshire & the Humber	0.023*	0.006
North west & Merseyside	0.039*	0.006
East Midlands	0.048*	0.006
West Midlands	0.007	0.006
Eastern	0.088*	0.007
London	0.066*	0.006
South East	0.133*	0.005
South West	0.075*	0.006
Wales	0.014*	0.007
Scotland	0.057*	0.006
Δhouse price x young	0.220*	0.024
Δhouse price x middle-age	0.243*	0.016
Δhouse price x old	0.063*	0.019

* = significant at p=0.05; omits coefficients on occupations and monthly dummies;

N=249,675; R^2=0.50

9.3 Consumption elasticity to real house price levels

As a robustness exercise, I replicate the specification of Attanasio et al. (2009) that estimates the life cycle model with house prices in levels. I report the consumption elasticity to house price coefficients in table 15.

Table 15: Non-Housing Consumption Elasticity to Real House Price Levels

Variable	**Full sample**	**1978-2000**	**1992-2018**	**2001-2018**	**ABHL**
House price x young	0.119*	0.082*	0.159*	0.090*	0.161*
	[0.0063]	[0.0080]	[0.0091]	[0.0127]	[0.009]
House price x middle-age	0.119*	0.083*	0.159*	0.088*	0.163*
	[0.0063]	[0.0080]	[0.0091]	[0.0127]	[0.009]
House price x old	0.125*	0.087*	0.167*	0.089*	0.165*
	[0.0063]	[0.0080]	[0.0091]	[0.0127]	[0.009]

* = significant at p=0.05; standard errors in brackets; ABHL are the coefficients from the initial

Attanasio et al. (2009) paper

9.4 AIDS derivation

Starting with the AIDS expenditure function:

$$\ln e(p_t, U_t) = \alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_{it} \ln p_{jt} + U_t \beta_0 \prod_i p_{it}^{\beta_i}$$

where p_{it} is the price of good i at time t, U_t is utility at time t, and α, β and γ are coefficients to estimate. By applying Shephard's Lemma and replacing the unobservable utility term with an indirect utility function that corresponds to the expenditure function, we can then derive Marshallian demand function in terms of x_{it} for the quantity consumed of good i at time t in terms of total expenditure m and prices:

$$x_{it}(p_t, m_t) = \frac{m_t}{p_t} \left(\alpha_i + \sum_j \left(\frac{1}{2}(\gamma_{ij} + \gamma_{ji}) \right) \ln p_{jt} + \beta_i \ln \left(\frac{m_t}{P_t} \right) \right)$$

where P_t is a translog price index: $\ln P_t = \alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2} \sum_i \sum_j \left(\frac{1}{2}(\gamma_{ij} + \gamma_{ji}) \right) \ln p_{it} \ln p_{jt}$, and γ_{ij} is $\frac{1}{2}(\gamma_{ij} + \gamma_{ji})$ if symmetry is imposed.

The final step is to simplify the Marshallian demand equations by expressing them as expenditure (budget) shares $w_i = \frac{x_{it} p_{it}}{m_t}$:

$$w_{it} = \alpha_i + \sum_j \left(\frac{1}{2}(\gamma_{ij} + \gamma_{ji}) \right) \ln p_{jt} + \beta_i \ln \left(\frac{m_t}{P_t} \right)$$

To incorporate demographic variables based on Ray (1983), m_{0h} is defined as the ratio of the expenditure required to obtain a certain utility level at given price p for household h with z demographic features, relative to the expenditure of a reference household R:

$$e(u, p, z) = m_{0h}(z, p, u) e^R(u, p)$$

The key assumption of this approach is the impact of demographic variables on budget shares is independent of total expenditure. Therefore, m_{0h} can be decomposed into two factors: $\bar{m_0}(z)$ which captures the change in household expenditure as a function of demographic variables only, and $\phi(p, z, u)$, which captures changes in relative prices

and actual goods consumed, so that:

$$e(u,p,z) = \bar{m_0}(z)\phi(z,p,u)e^R(u,p)$$

The derivation of demand functions from expenditure functions then follows as above for the regular AIDS model

9.5 Elasticity formulas

The equations for income, compensated price and uncompensated price elasticity as derived from QUAIDS models are listed below. They can be obtained by differentiating the budget share equation with respect to total income and prices. I omit the algebraic details of the derivation, but the elasticity formulas are listed below. The notation is from Poi (2012).

The income elasticity for good i μ_i is:

$$\mu_i = 1 + \frac{1}{w_i}\left[\beta_i + \eta_i^{'}\mathbf{z} + \frac{2\lambda_i}{b(\mathbf{p})c(\mathbf{p},\mathbf{z})}\ln\left\{\frac{m}{\bar{m_0}(\mathbf{z})a(\mathbf{p})}\right\}\right]$$

Where $b(\mathbf{p})$ is the Cobb-Douglas price aggregator $\prod_i p_{it}^{\beta_i}$, $\ln a(\mathbf{p})$ is the transcental logarithm function: $\alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2}\sum_i\sum_j \gamma_{ij}\ln p_{it}\ln p_{jt}$, $c(\mathbf{p},\mathbf{z})$ is the Cobb-Douglas price aggregator scaled by the demographic variables $\mathbf{z}$: $\prod_{j=1}^{k} p_j^{\eta_j^{'}z}$, w_i is the budget share of good i, m is total expenditure and $\bar{m_0}(\mathbf{z}) = 1 + \rho^{'}\mathbf{z}$ and is a component of the function that scales expenditure function to account for the household characteristics.

The uncompensated price elasticity for good i with respect to a price change of good j, ϵ_{ij}^U, is:

$$\epsilon_{ij}^U = -\delta_{ij} + \frac{1}{w_i}\left(\gamma_{ij} - \left[\beta_i + \eta_i^{'}\mathbf{z} + \frac{2\lambda_i}{b(\mathbf{p})c(\mathbf{p},\mathbf{z})}\ln\left\{\frac{m}{\bar{m_0}(\mathbf{z})a(\mathbf{p})}\right\}\right] \times \left(\alpha_j + \sum_i \gamma_{ji}\ln p_i\right)\right)$$

$$-\frac{1}{w_i}\left(\frac{(\beta_j + \eta_j^{'}\mathbf{z})\gamma_i}{b(\mathbf{p})c(\mathbf{p},\mathbf{z})}\left[\ln\left\{\frac{m}{\bar{m_0}(\mathbf{z})a(\mathbf{p})}\right\}\right]^2\right)$$

Where δ_{ij} is the Kronecker delta, taking the value of 1 if $i = j$ and zero otherwise. Finally, the compensated price elasticity for good i with respect to a price change of

good j, ϵ_{ij}^C, can be derived from the Slutsky equation:

$$\epsilon_{ij}^C = \epsilon_{ij}^U + \mu_i w_j$$

9.6 Deriving Compensating Variation

This derivation is based on Friedman and Levinsohn (2001). We start with the expenditure function $C(p, u)$. Taking a second order Taylor expansion of the minimum expenditure function with respect to price:

$$\Delta C \approx q\Delta p + \frac{1}{2}\Delta p^T s \Delta p$$

Where p is a vector of price changes for n goods, q is a vector of consumption good quantities, and s is the n x n matrix of compensated derivatives of demand. This expression can be re-written in terms of budget shares and logarithms:

$$\Delta \ln C \approx \sum_{i=1}^{n} w_i \Delta \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}\Delta \ln p_i \Delta \ln p_j$$

where $c_{ij} = P_i s_{ij} p_j / C$, and s_{ij} is the Slusky derivatives. With some algebraic manipulation, it can be shown that $c_{ij} = w_i \varepsilon_{ij}$, resulting in the expression:

$$CV \approx \sum_{i=1}^{n} w_i \Delta \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} w_i \varepsilon_{ij}\Delta \ln p_i \Delta \ln p_j$$

where w_i is the budget share of commodity i (out of n different commodities) in the initial period before the price change, $\Delta \ln p_i$ is the change in price of good i and ε_{ij} is the compensated price elasticity of commodity i with respect to the price change of good j,

9.7 QUAIDS estimated using instrumental variables

Table 16: First Stage IV Regression - Young Household Sample

Variable	cons.	food price	housing price	fuel price	leisure price	o. goods price	o. services price	income	income squared	no. kids	no. adults	cohort	region
Expenditure	4.556*	0.173	0.432*	-0.117*	-0.014	-0.192	0.948*	0.003*	0.000*	-0.028*	0.257*	0.006*	-0.055*
	[0.034]	[0.111]	[0.029]	[0.025]	[0.096]	[0.107]	[0.142]	[0.000]	[0.000]	[0.002]	[0.005]	[0.001]	[0.003]

* = significant at p=0.05; standard errors in brackets, coefficients from income variable in second stage shown earlier in text

Table 17: Expenditure coefficients from 2nd stage of 2SLS regression for each demand equation

Good$_i$	**Coefficient**	**st. error**	**P-value**
Food	-0.004	[0.002]	0.006
House	-0.056	[0.003]	0.000
Fuel	-0.002	[0.001]	0.058
Leisure	0.013	[0.003]	0.000
Other goods	0.039	[0.003]	0.000
Other services	0.010	[0.003]	0.002

Null rejected if $p < 0.05$

Table 18: Parameter estimates of QUAIDS estimation - Second Stage IV Estimation
Young Household Sample

$Good_i$	α_i	β_i	γ_{1i} (food)	γ_{2i} (house)	γ_{3i} (fuel)	γ_{4i} (leisure)	γ_{5i} (goods)	γ_{6i} (services)	λ	no. kids	no. adults	cohort	region
Food	0.803*	-0.186*	-0.111*	0.318*	-0.105*	-0.083*	0.026	-0.044	0.011*	0.032*	0.030*	-0.007*	0.001*
	[0.018]	[0.007]	[0.015]	[0.015]	[0.006]	[0.016]	[0.018]	[0.023]	[0.001]	[0.000]	[0.001]	[0.000]	[0.000]
Housing	-1.045*	0.515*	0.318*	-0.752*	0.386*	0.135*	0.044	-0.131*	-0.051*	-0.027*	-0.015*	0.002*	0.002*
	[0.033]	[0.013]	[0.029]	[0.042]	[0.012]	[0.034]	[0.038]	[0.048]	[0.001]	[0.001]	[0.002]	[0.001]	[0.000]
Fuel	0.728 *	-0.233*	-0.105*	0.386*	-0.125*	-0.103*	-0.076*	0.023	0.020*	0.010*	0.004*	-0.001*	0.000*
	[0.010]	[0.004]	[0.009]	[0.012]	[0.005]	[0.011]	[0.012]	[0.015]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
Leisure	0.284*	-0.114*	-0.083*	0.135*	-0.103*	0.088*	-0.240*	0.203*	0.018*	-0.008*	-0.013*	0.003*	-0.001*
	[0.032]	[0.012]	[0.024]	[0.024]	[0.009]	[0.026]	[0.029]	[0.038]	[0.001]	[0.001]	[0.002]	[0.001]	[0.000]
Other	0.326*	-0.039*	0.026	0.044*	-0.076*	-0.240*	0.056*	0.190*	0.001	0.002*	0.013*	0.002*	-0.001*
goods	[0.030]	[0.011]	[0.023]	[0.022]	[0.009]	[0.024]	[0.028]	[0.037]	[0.001]	[0.001]	[0.002]	[0.001]	[0.000]
Other	-0.097*	0.057*	-0.044*	-0.131*	0.023*	0.203*	0.190*	-0.240*	0.002	-0.007*	-0.019*	0.000*	0.000*
services	[0.036]	[0.014]	[0.026]	[0.024]	[0.011]	[0.028]	[0.033]	[0.043]	[0.001]	[0.001]	[0.002]	[0.001]	[0.000]

* = significant at p=0.05; standard errors in brackets