

## Article

# Private Renting vs. Mortgage Home Buying: Case of British Housing Market—A Bayesian Network and Directed Acyclic Graphs Approach

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**Abstract:** The worsening of housing problems in many countries has become a topic of global interest. Researchers point to a variety of factors that influence individual housing tenure decisions. Our study is based on longitudinal English Housing Survey (EHS) data (2008–2009 to 2019–2020, with survey years matching financial years, i.e., running April–March) and identifies flows between different forms of housing tenure in the U.K. and analyses conditional dependencies of a range of EHS variables using a directed acyclic graph (DAG). More specifically, we take into account variables such as first-time buyers (FTB), mortgage payments, rent payments, share of mortgage/rent in household income, and receipt of housing benefit (HB), with some variables also reflecting a regional breakdown (captured separately for London and England excluding London) to illustrate the complex nature of regional differences in explaining changes in housing tenure. We address some of the problems and challenges of the housing market in the U.K. today, and, in particular, examine what influences private renters and those buying with a mortgage. A key conclusion from this study is that housing benefit does not necessarily ease the way for private renters into their own housing. The study is quantitative in nature and uses the English Housing Survey and Bayesian network (BN) analysis. Unlike traditional methods, such as multiple regression or panel regression, where the researcher somehow suggests the type of a relationship between certain variables, BN's learning algorithm analyses different iterations between variables and finds the most appropriate relationships between them.

**Keywords:** housing tenure in U.K.; private renters; buying with mortgage; Bayesian network (BN) analysis; directional acyclic graph (DAG)



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## 1. Introduction

In the U.K. market, there has been a multi-year process of relevant shifts in the structure of housing tenure [1–3]. For a number of years, the private rented sector (PRS) has been growing, whereas the owner-occupier market has been shrinking [1]. This has been highlighted by various researchers, including Clair [4], Mulheirn [1], Rugg and Rhodes [2], and Balchin and Rhoden [3].

Interestingly, despite an adequate supply of housing, the availability of housing on the U.K. market for certain groups of people is consistently declining [1]. This mainly affects young adults [5]. A similar problem has been described in other studies covering other countries [6,7]. These problems obviously have their causes, namely for the British market: the erosion of the social housing stock, the stagnation of young people's incomes, and the policy of reducing housing benefits, which mainly affects young adults and single individuals.

Unfortunately, such problems cannot be solved by building more dwellings and thereby increasing the supply of housing in the market sector. Some solutions already

exist and have been applied, yet they should be properly oriented. For example, the state can create more social housing [3]. However, getting people used to social benefits has not been devoid of drawbacks either. On the other hand, a tighter labour market and stronger economic growth, which would be a solution in the context of alleviating housing affordability problems, already depend on the state of the economy, which is subject to economic cycles. Of course, a better economy would translate into a better economic situation for young people, but such a conclusion is trivial.

Similar problems are currently faced by many countries; however, for all intents and purposes, the U.K. market can be perceived as the focal point of most of the problems faced by many other countries. This is one of the reasons why we are specifically examining the U.K. market. Another reason is the availability of data; it has to be objectively acknowledged that the data for the UK housing market (which can be retrieved from EHS) are, in any case, the most robust amongst all European countries (the survey is cyclical and very comprehensive), and this is also an important point of motivation to study the U.K. market.

Based on the extensive EHS database (with a very large number of variables), the aim of this study is to examine the apparent flows between housing tenure in the context of various variables that find their substantive justification and some theoretical background (either analysed before or which seem to be a reasonable educational guess), i.e., recent first-time buyers (FTB), mortgage payments, rent payments, mortgage/rent as a proportion of household income, receipt of housing benefit (HB), and some variables reflecting regional breakdown (since many measures provided in the EHS are covered separately for London and England excl. London), which would address the complex nature of regional disparities in the context of explaining variations in housing tenure shifts.

More specifically, from a scientific point of view, we hypothesise that given the regional distribution (London and England outside London), the relationships between different housing tenures and a range of variables included in the study, the results will vary significantly, thus confirming the complex nature of this market. Typically, this type of study can be conducted by means of a panel regression analysis with the use of longitudinal data, but since there are many variables that we introduce into the study, a more legitimate methodology seems to be Bayesian networks [8–10], which is one of the four acknowledged methods of machine learning, that are based on learning algorithms and that, thanks to the ubiquity and omnipresence of a large amount of data in our modern life, are increasingly replacing human beings in the diagnosis of certain problems and forecasting.

It is worth emphasising that today's world is crammed with data that are readily available to everyone. The problem is, however, how to derive meaningful inferences from such data. This might require the use of machine learning tools, such as classifiers, data clustering, etc. Many of these approaches yield models that accurately describe the data, yet they can be difficult to interpret. To understand the results more intuitively, it is useful to use the BN method, a graphical representation that simplifies the complex mathematical model to the most likely pattern of relationships between variables. In this sense, the analysis of many different EHS data using this particular method seems eminently reasonable.

Bayesian networks are based on a probabilistic model and explain relationships between variables in a relatively simple way. Moreover, BN is a graphical model in which conditional dependencies between variables are easily visualised by a directed acyclic graph. Thanks to these aforementioned features, BNs are growing in popularity and the algorithms that are used in them are capable of learning and making inferences. Still another important feature of this research method is that it can be applied in virtually any field where variables are dealt with and relationships between them are studied. Thus, probabilities can be estimated, indicating that a given cause is behind a given outcome.

In the paper, we review the literature and point out some aspects of the British housing market that are important, describe the research methodology and the variables associated with the empirical study, and finally present the discussion of the results and conclusions.

The structure of the article is as follows. In Section 2, we focus on theoretical issues related to the topic of the study. We begin by outlining the factors determining housing

tenure choices and conclude by presenting general characteristics of the British market in order to better address its complex nature. In Section 3 (empirical), we overview the overall characteristics of the EHS, present key analytical insights from the EHS survey, and discuss the BN research method. In the following Sections 4–7, we present the results, conduct a discussion, make a summary (in the conclusion section) and indicate the limitations of the study.

## 2. Theoretical Background

### 2.1. Determinants of Individual Housing Tenure Choices and Benefits of Home Ownership

Firstly, it should be noted that the importance of home ownership and housing studies are fairly well established in the literature [11–17]. Mackie [16] makes the point that the exacerbation of housing problems in many countries is widely reported and has become a subject of global interest. More importantly, it raises important housing policy questions. Researchers point to a wide variety of factors that influence people’s decisions on home ownership or private renting [18,19]. For example, Jacobsen and Monteiro [20] argue that among economic, social and cultural factors, the former ones are predominantly influential with regards to housing decisions/choices, whereas the latter seem to have a minor impact on such choices. Chaney and Emrath [21] highlight factors such as income and wealth, housing prices, interest rates and relevant tax policies.

Malmendier and Steiny [22] provide evidence that there is a positive correlation between home ownership and experienced inflation. It is often argued that owning a home, as opposed to renting, brings certain social and economic benefits. Haurin et al. [14] point to better social outcomes, a decrease in criminal activity, a favourable environment for creating a family or higher levels of educational achievements. For example, Zumbro [23] provides evidence supporting the positive relationship between home ownership and life satisfaction. Greater life satisfaction is also indicated by the results of the EHS (Table A18 in the Appendix A). By the same token, Green et al. [13] see home ownership as contributing to fewer pathological incidents among adolescents. Still another group of researchers stresses that home ownership increases general civic awareness [11,15,17]. Thus, there is much evidence of a non-economic nature supporting the superiority of home ownership over renting [19]. Rowlands and Gurney [24] analyse people’s perceptions of housing issues relying on the interviews conducted with them. Their results point to some economic, political and cultural dimensions of consumption as the factors/aspects impinging on the problem of home ownership and attitudes towards ownership. Therefore, they postulate the need for numerous debates and information awareness campaigns on this topic in the society, since it is the housing socialisation process that influences possible prejudices and negative/positive perceptions about home ownership [24]. Rowlands and Gurney [24] discuss the importance of the socialisation of housing preferences, which translates into subsequent housing policies and also shapes the development of theoretical debates in this area. In general, past research has shown that it is preferable for people to own a home rather than rent it, assuming, of course, that they can afford it. Rohe et al. [17] note that surveys show that Americans typically prefer owning to renting. According to one such study, 86% of respondents answered that they prefer home ownership compared to renting, and 74% that they would opt for home ownership only if they could afford it. In the same survey, 67% of surveyed tenants claimed they were renting a home because they could not afford to own one, whereas for 57%, purchasing a home was an important life priority, and only for 26% renting was entirely a matter of life choice.

According to Beracha and Johnson [18], home ownership is a signifier of wealth and it also fulfils people’s fundamental purpose in life, increases self-esteem, and results in a greater sense of civic pride. Home ownership can also be linked to social factors, such as crime prevention, child development and educational benefits. In turn, Mulder and Billari [25] point out that countries with a “difficult home ownership regime” tend to also have lower fertility rates (difficult home ownership regime is as a combination of a high share of home ownership with low access to mortgages). Beracha and Johnson [18] argue

that modern economy and politics, which are structured in such a way so as to crowd people into home ownership, have simultaneously elevated housing prices far above their basic value, making it increasingly difficult to buy (fewer and fewer people can afford it). Pierre Bourdieu's study allows us to understand the consequences of the loss of affordable urban housing, which in turn cannot be ignored by policymakers in shaping housing policies [26].

Filandri and Bertolini [27] compared experiences from different European countries with regards to home ownership. In their study, they took into account both macro and micro determinants, including the impacts of the housing system, the labour market, the nature/status of the welfare state, and the quality of social class. Their results show that the social class and socio-economic background play an important role. Thus, people from the middle class were found to be more likely to own their own homes compared to those from the lower and upper classes. More importantly, Filandri and Bertolini [27]'s study provides evidence in that there is negative association between state benefits and the level of home ownership; home ownership itself has much to do with the socialisation and education of young individuals coupled with family values, which portray the home as an asylum and a symbol/status of safe haven, emphasising the importance of social class of origin. As a general rule, the levels of home ownership are significantly higher in those countries where the family is traditionally associated with social safety and increased stability. This particularly is true in those countries where the home is traditionally viewed as a social safety net.

According to Fuster et al. [28], home ownership is currently regarded more as a life burden and a financial risk than stability and security. Additionally, discourses on various forms of housing tenure take a different course, and choices in this respect are made today under conditions of high uncertainty, such as economic uncertainty, price instability in the housing market, uncertainty in relationships, uncertainty about tomorrow and events, such as COVID-19, other binary events, etc. [29]. This in turn has caused a shift in the way people look at different forms of housing tenure. Hence, it should not come as a surprise that renting is now more often viewed as providing greater flexibility and security.

In addition, Flynn [30] points out that compared to previous generations, people are finding it increasingly difficult to accommodate their housing preferences, which is evident even in countries with good economic conditions and relatively well-developed, stable and liquid housing markets. Furthermore, housing markets are also strongly influenced by inequalities in income and wealth levels. As is well known, inequality is never good for any given market, resulting in social exclusion and the marginalisation of many individuals.

Beracha and Johnson [18] also argue that if the average length of home ownership of American families is taken as a reference point, renting a house is the better option compared to home ownership. However, when making such a comparison, it is important to remember that the uniqueness of the local market is of great importance. It is therefore difficult to draw conclusions for the European market from such a comparison for the American market. Firstly, the very physical characteristics of the existing housing stock are different. Other important issues which make such comparisons impracticable are geography, demography and, finally, social habits. All these factors must be reflected in government policies (and the corresponding legislation that follows), and more importantly, since housing conditions themselves change, policies will also vary from country to country. Government policies themselves are the result of various political compromises. Their harmonisation, even at the European level, is therefore impossible, let alone a world-wide harmonisation. Conducting research and analysis based solely on a selected factor, ignoring the complex nature of these markets, will always lead to distorted assessments of reality or its selective fragments [21].

Beracha and Johnson [18] recommend adopting a position of impartiality between buying and renting and making appropriate decisions, taking into account rent-to-price ratios with property appreciation rates and housing prices volatility.

Barrios et al. [31] highlight the number of positive aspects associated with home ownership, both at micro and macro levels. From the micro perspective, home ownership clearly promotes greater savings in households and leads to greater social participation. On the other hand, at the macroeconomic level, it affects consumption, investment and public finances.

## 2.2. Economic, Social and Cultural Environment

The last few years, however, have been a period of turbulent transformations in housing markets, caused initially by the collapse of housing bubbles as a result of the subprime crisis, which subsequently led to general post-crisis economic uncertainty and difficulties in accessing mortgage finance [32]. It is worth noting that housing crises are usually accompanied by a decline in home ownership rates. If we take the United States as an example, the home ownership rate averaged there in 1990 at about 64%, and gradually increased to about 68% by the time of the housing crisis from more than a decade ago. The housing crisis began in 2007 and it led to a sharp and rapid decline in the home ownership level to around 63.5% [33] (according to ACS data). With regards to housing crises, Davies [34] pointed out the low resilience of primarily those countries (regions) that had high levels of construction employment, and in particular, the ones that were affected by asset bubbles. One such country was Spain, for example. Mínguez [6] points to forces related to housing transformations affecting tenants in Spain. She examined the impact of the financial/housing crisis from a decade ago on the housing challenges and transformations currently faced by people in Spain. It appears that in the post-crisis period, there is an increasing inclination towards renting compared to home ownership. It manifests itself in a higher proportion of rented dwellings and a change in preference towards renting, which is visible in the declarative sphere. Mínguez [6] shows how the housing situation in Spain (especially after the 2008–2009 crisis) negatively translates into various socio-economic challenges, including individual autonomy and family formation, which have direct implications on the emancipation of young adults. Lennartz et al. [35] argue that when housing dynamics is contrasted with changes in aspirations and norms, it can trigger some significant social impacts. The direction of these changes can vary strongly across countries, but it proves to be the case particularly in those countries where the crisis disrupted pre-existing housing patterns and forced a change in living arrangements and lifestyles among younger generations.

Malmendier and Steiny [22] showed that there is a certain relationship between macroeconomic experiences and microeconomic decisions of individuals (households) in terms of their inclination towards home ownership (which impinges on households' tenure choices). In short, households exhibit some heterogeneity over inflation expectations, which is a result of the tendency to factor in their own individual experiences, and it is largely due to this heterogeneity that we can understand the variation in the probability of being a homeowner. Malmendier and Steiny [22] found a relationship between experienced inflation and home ownership both within and across countries. Such experienced inflation is perfectly illustrated by the example of immigrants who, while moving to a completely different housing market (previously unknown to themselves), concomitantly tend to make decisions that are more in line with their prior experiences rather than with the specific economic conditions prevailing in their countries of destination [22]. The authors note that monetary policy decisions may have long-lasting effects on future home ownership rates. Decisions to buy or rent a home are strongly influenced by past experiences related to macroeconomic turbulences. In this context, it is important to keep in mind that London is a specific housing market, since it has the highest number of migrants of all U.K. regions. These facts deserve some attention, as migrants may carry some negative macroeconomic experiences from their own countries, and therefore, a regional disaggregation is relevant when examining the British housing market. According to Vargas-Silva and Rienzo [36], this number is as high as 3,317,000 or 35% of the total foreign-born population. In contrast, according to Rugg and Rhodes [2], 80% of migrants from other countries live in the PRS,



with London having a much higher proportion of migrants compared to other parts of England. London is, therefore, a market that, by its very nature, gravitates towards renting as opposed to other regions of England [2].

It is important to notice that apart from economic factors contributing to the variation in housing prices and supply, there is a whole host of other aspects that should also be taken into account, such as institutional differences, demographic factors, housing policies, cultural factors, etc. [22]. Similarly, Hargreaves [37] points out that choices of whether to own or rent a home are often driven by non-financial reasons, which can be associated with, i.a., “lifestyle” and cultural heritage. Hargreaves [37] even developed a financial model contrasting the economics of owning and renting a home. He also analysed the labour market and social changes (in New Zealand), resulting in renting preferences. His model draws on probability and risk analysis, with housing prices being the key financial variable in the model. It addresses the reasons behind the significant increase in the proportion of renting rather than owning homes in New Zealand. These reasons include the uncertainty of future income due to job insecurity, delayed decisions about starting new families, and a change in the previously dominant family model, manifested by an increasing number of single-person households (i.e., single parents and single-person households). For a number of years, price affordability was more conducive to owning a home than renting one. Over the last two decades, however, prices have skyrocketed in many countries. For example, Greenaway-McGrevy and Phillips [38] provide evidence of episodic bubbles in housing market in New Zealand over the past two decades. By the same token, the Australian housing market exhibits significant evidence of an exuberant rise in housing prices, especially when compared to renting [39]. Unfortunately, modern economies are driven by artificial monetary creation, and part of such excessive liquidity injected into the system trickles down to the housing markets and alternative assets markets [40]. Kholodilin and Michelsen [41] point to speculative investment behaviour and serious concerns about the existence of housing bubbles in 8 out of 20 OECD countries, including the United States and the U.K. The American FED, which had once established certain direction in this regard, is to some extent responsible for this situation. In this vein, Vogiazas and Alexiou [42] provide evidence of the impact of credit-driven economies on the propagation of housing booms and bubbles. According to Thornton [43], the widespread housing bubbles and the lack of housing affordability are signs of a housing crisis and a failure of governments, whose policies are the main reason why houses/dwellings are now virtually beyond the economic reach of first-time buyers. Moreover, assuming that interest rates will rise in the next few years (and this cannot be ruled out), housing prices will most likely fall, which in turn will reveal the truth about many misguided investments, and many life dramas of people who made unwise and irrational decisions. For example, Druta and Ronald [5] studied housing affordability in the U.K. They found that worse price affordability means that young adults’ entry into home ownership is now more frequently achieved through parental support, which takes the form of financial transfers (e.g., loans) or in-kind transfers. Filandri and Bertolini [27] compared experiences in different European countries in this regard and found evidence of an increasing role for the socio-economic background of the family. Young adults from wealthier families are more likely to become homeowners. On the other hand, givers exercise control over recipients by promoting normalised choices [5]. By the same token, Öst [44] points to the problem of housing affordability and that first home ownership is often associated with family background and its material status. In today’s housing markets, with low affordability, parental wealth plays an important role in young adults’ emancipations from their families. Thus, there is much evidence indicating that young adults’ only chance is to rely on parental support, and their chances can be attributed to the socio-economic status of their parents. Öst [44] notes that both insufficient price affordability and a range of other housing market issues make parental home ownership an important predictor of whether and when young adults will transition to first-time home ownership. Coulter [45] argues that differences between young adults whose parents are more and less socioeconomically advantaged

become even more pronounced as house prices rise. In addition, this phenomenon is more pronounced in the case of women [45]. This is also evidenced by Lee et al. [46], whose study shows that those young adults whose parents are more affluent are more likely to buy homes. Prior research shows that young adults are somehow forced to live with their parents or become renters [35,46]. Parental financial transfers increase young adults' chances of buying their own home [35,46]. The U.S. Health and Retirement Survey (HRS) data show that a USD 5000 transfer (or higher) received from parents for any purpose increases the likelihood of young adults buying their own home by 15%. Taking the U.K. market as an example, Coulter [45] showed that it is the financial constraints that make parents increasingly impactful on young adults' emancipation and home purchase. The fact that young adults have less access to housing, which is particularly true in low-affordability housing markets, translates into housing inequality, reduced social mobility, and an increasing intergenerational transfer of wealth. This is particularly pronounced in expensive housing markets, where access to ownership is often more limited [45]. This phenomenon also affects women more than men.

A key determinant of housing prices is the cost of capital, which is determined by the interest rate policy pursued by central banks. Low mortgage rates explain the high prices of properties, the valuations of which are conducted with the use of discount methods, accounting for the present value of the annuity they will generate. Thus, as the capitalised value of future rent payments rose as the risk-free rate fell, so did house prices. On the one hand, the total cost borne by owner-occupiers remains relatively balanced and constant [1]—along with the changing market circumstances (increase in housing prices, but also decrease in the interest rate on mortgages and increase in income—for the Polish market, this was shown by Sobieraj and Metelski [40]). The situation is similar with the rent payments.

Simultaneously, the so-called wealth effect and asset concentration are playing an increasingly important role in modern economies. For most homeowners, this means that the homes they own are their largest asset and often their only asset. In short, there is a concentration of huge risks which ordinary households are exposed to. With a long cycle of rising housing values, this type of risk is attractive and tempting (luring) to embrace. However, it is impossible not to notice that households which are subject to this situation are not well protected against the consequences of risk (which does not only mean benefits, but also the possibility of losing the wealth or its part) [1,3]. Mulheirn points out that, particularly in the U.K. market, it has been instilled in people to believe that housing transactions are one-way bets.

### *2.3. State Support (Housing Policy) and Mortgage Financing System*

Apart from price affordability, another important issue that resonates with housing tenure trends is government policy. For example, Filandri and Bertolini [27] provided evidence showing an important role of social policy on people's ownership status. They found that excessive state welfare support translates negatively into home ownership rates. Dietz and Haurin [11] studied the economic and social consequences (effects) of home ownership. Their findings show that home ownership is important when viewed from the state's perspective, translating into household wealth, mobility, urban structure and segregation, labour force participation, home maintenance, demographics, health, political and social activities, self-esteem, education, and other outcomes. They also point out that there is a lack of literature that examines these aspects from an econometric perspective. McKee [47] argue that housing policy has an important impact on wide-ranging social, economic and demographic changes and has to be viewed in the context of building wealth. Therefore, it plays an important role in shifts from collective to asset-based welfare [47]. More often, housing issues create intergenerational conflicts between young adults who cannot afford home ownership and elderly people who already own their own homes. To address this, it is necessary to develop housing policies that interact with wider social, economic and demographic changes and touch on such issues as wealth creation and welfare.

In turn, Flynn [30] analysed the relationship between national governments' housing policies (she took 20 high-income OECD countries) and the emancipation of young adults from their parents. The results showed that young people manage to leave their family homes earlier and more easily especially in those countries where governments create solutions (policies) that facilitate easier access to efficient, stable, and liquid mortgage markets [30]. The importance of providing adequate financing instruments for the housing market was also argued by Chiuri and Jappelli [48], who showed the relationship between the availability of mortgage financing (measured by money-down payments ratio) and housing purchases. How important the mortgage financing system is (and how it can possibly be redesigned to reduce housing market volatility, consumption volatility and the number of mortgage payment defaults) was studied by Guren et al. [49], who in their study compared FRM (fixed-rate mortgage) and ARM (adjustable-rate mortgage) systems and provided evidence showing how important loan repayment flexibility is for the perspective of the entire housing market. Their study shows that the most appropriate form of financing is an ARM loan, and if a home purchase is financed with FRM loans, they should have built-in options which allow for their conversion to ARMs with a possibility to refinance at the prevailing FRM rates. The idea is that the housing financial system which typically raises mortgage payments during booms and lowers them during recessions is better than the one with fixed mortgage payments. It translates into lower arrears for the system as a whole and stimulates demand for housing from new buyers [49].

Barrios et al. [31] examined the characteristics of property taxation in European countries and the United States (between 1995 and 2017), including issues such as taxes on the acquisition/transfer of residential property, permanent household taxes, capital gains taxes, rent-related taxes and mortgage-related tax credits. They estimated owner-occupied housing costs, which synthetically reflect distortions of the tax system in the context of housing investment. They relied on the methodology proposed by Poterba [50,51] and Poterba and Sinai [52]. Their study provides a range of additional evidence, including maximum loan-to-value ratios and maximum loan durations, interest rates on long-term government bonds, income tax on interest, and house prices. Poterba [51] and Poterba and Sinai [52] investigated how distortions in the tax system affect household housing decisions. They studied how unfavourable tax laws (government policies) affect the utility costs of owner-occupied housing. Their conclusion is that the state (state policy) should be oriented towards lowering marginal tax rates, which leads to a reduction in deadweight losses which favours home ownership in general (deadweight loss occurs when supply and demand are not in equilibrium, which leads to market inefficiency). Additionally, Desmond [26] highlights the increasing rent burden among low-income households. All in all, the cost of home ownership for households is influenced by state policies on income tax. A state that seeks to support (promote) homeownership generally is expected to be focused on creating legislation that provides tax deductibility for mortgage interest and propensity tax payments and makes tax regulations that interact with capital gains from home ownership [26]. Experts emphasise the exclusion of imputed rental income on housing as a key tax benefit for owner occupiers. Desmond [26] also outlines the benefits to homeowners resulting from appropriate government tax policies, i.e., mortgage interest deductions, property tax deductions, etc.

#### 2.4. Boom in Private Rented Sector (PRS)

Goodman et al. [33] predict that the processes we are currently experiencing will result in fewer and fewer new household formations in the current decade (between 2020 and 2030). However, the number of elderly households will grow rapidly. Home ownership levels are expected to decrease. In addition, Goodman et al. [33] argue that net new household formation will result in an increase in the absolute number of homeowners; however, the absolute number of renters is expected to increase even faster. Put differently, the future housing market is expected to be a renters' market, which will become reflected



in the number of new renter households, which at some point in the future will outweigh the number of new owner-occupied households [33].

It seems reasonable to assume that increasingly difficult access to home ownership would result in a boom in the renting sector. Lennartz et al. [35] find that this is not entirely true, and what we are currently dealing with is not a “generation of tenants”, but rather an increasing proportion of young adults living with their parents. These are important trends that are shaping housing markets in the U.K., Europe and globally [35]. Lennartz et al. [35] point to a larger post-crisis decline in the number of European young adults owning a home (they surveyed 18–34-year-old individuals from 15 EU countries), which they attribute to worse labour markets. They also highlight the changing nature of housing markets themselves, which have become increasingly financialised, making it significantly more difficult and sometimes even impossible to pursue home ownership.

Rugg and Rhodes [2] emphasise the inferior housing conditions of renters, which is relevant because it raises some health service implications (deferred in time). According to these authors, although there has been a slight improvement in this area recently, the vast majority still fail to meet the relevant standards (the so-called Decent Homes Standard). There are an estimated 1.35 million such privately rented dwellings that do not meet the minimum standards. In comparison with other types of housing tenure, according to the Family Resources Survey [2], the PRS also has the highest proportion of children under the age of five (reaching approximately 20%). This situation in a straight line leads to a health disaster.

Rugg and Rhodes [2] stress the negative health effects of living in such reduced standard housing in the long term. They describe the lowered standards very matter-of-factly, pointing to damp and mouldy dwellings with very reduced thermal comfort.

By the same token, Tajani et al. in their study [52] show that with the onset of the pandemic (the effects of which will take years to emerge), both thermal and acoustic comfort become increasingly important. Although Tajani et al. [52] refer to the Italian market, their reasoning logic can be transferred to the U.K. market. In any case, this issue should not be ignored in the context of the U.K. market. Tajani et al. [52] argue that decisions to choose appropriate housing tenure are also, to some extent, dictated by the characteristics of domestic spaces, which becomes particularly important in the context of the COVID-19 pandemic. This is due to the forced changes that the pandemic has brought to various aspects of human life (work, social life, training and schooling, etc.). In the context of the findings of Tajani et al. [52], the desire to buy a dwelling far away from the hustle and bustle of a big city (which is, for example, London) seems relatively rational. This may also be one of the reasons why more and more people (mainly older retired people will move out of London to other regions of England).

### *2.5. British Housing Market and Its Complex Nature*

In particular, it is worth highlighting the extremely complex nature of the U.K. housing market, as described in detail by Mulheirn [1] and Balchin and Rhodes [3], involving, i.a., the changing housing tenure structure of this market over the last decade or so, which is also highlighted by Clair [4] and Rugg and Rhodes [2]. A good characterisation of the U.K. housing market is provided by Mulheirn [1] and Balchin and Rhoden [3], who point to, among several problems of this market, the collapse of the owner-occupied sector, the transfer of housing from local authorities to registered social landlords, the phasing out of renovation grants, the increasing brownfield developments, social exclusion, homelessness, etc.

Teye and Ahelegbey [53] highlight the increasingly common phenomenon of housing spatial diffusion in the U.K., indicating that the British market was one of the first markets for which this phenomenon was described. In this vein, Tsai [54] shows the spillover effect between the regional and the national housing markets in the U.K.

The U.K. market is experiencing a changing housing tenure structure. For a number of years, the PRS market (i.e., the private rented sector market) has been growing, while the

purchasing market has been shrinking (all owner occupiers). This is highlighted by various researchers, including Clair [4], Mulheirn [1] and Rugg and Rhodes [2].

Why is changing the structure of the housing market (by tenure) so important? Del Giudice et al. [55] point out that such a change (and this is the phenomenon we are facing in the U.K.) entails a number of other transformations beyond the housing-related perspective. For example, it can be reflected in the energy policy (consumption habits and behaviours are different for different tenures, and this will be reflected in energy consumption) and should even be integrated with environmental policies, as Marmolejo-Duarte and Bravi [56] demonstrate in their work.

Baptista et al. [57] analysed how the size of the rental and buy-to-let sectors and the different types of buy-to-let investors translates into prosperity in the U.K. housing market. They find that an increase in the size of the buy-to-let sector contributes to strengthening house price cycles and also increases their volatility. These authors highlight, i.a., the issue of the portfolio limit on lending relative to income in the context of macro-prudential policies. In their view, such a policy is necessary because it moderates the housing price cycle.

Best and Kleven [58] studied the impact of transaction taxes on housing markets based on data on housing transactions in the U.K. between 2004 and 2012. Their results showed that this type of tax creates large distortions in housing markets in terms of prices, quantities and transaction times. In addition, they provide a strong fiscal stimulus. Their partial reduction contributes to a significant increase in housing market activity.

### 3. Materials and Methods

#### 3.1. English Housing Survey

In the study, we use data from the English Housing Survey (EHS) covering the period 2008–2020. The EHS is an annual national survey commissioned by the Ministry of Housing, Communities and Local Government (MHCLG) [59,60]. It is a large, repeated cross-sectional survey that collects information on people's housing conditions and the state of housing in England [61]. Many national statistics are produced based on the EHS. More specifically, the EHS is a large-scale, complex survey with two phases: a survey of all selected dwellings and a visual inspection of a sub-sample of dwellings by a qualified surveyor. The EHS is conducted throughout England throughout the year. The sample is scientifically selected to represent the broad English population. The EHS has been conducted since 2008. Prior to this, data were collected as part of the Office for National Statistics (ONS). As for the EHS, 13,300 and 6200 households participate in this survey respectively. The difference is that in the first case (13,300 households) a full survey sample is conducted, while in the second case (6200) a physical examination of the sample of respondents (the so-called housing sample) is conducted. The EHS dataset provides access to unique observations of household characteristics, all determined by a variety of determinants. To ensure unbiased estimates, the EHS is appropriately weighted to account for over-coverage of less common ownership groups and differential non-response [62].

Clair [4] notes that initially, the EHS survey was conducted annually and covered 17,000 households through face-to-face interviews on their housing situation, taking into account the receipt of housing benefits and 8000 dwellings once every two years as a physical inspection of housing conditions. Since 2011–2012, the sample size has been reduced and clustered accordingly, which is justified by the cost savings. The survey corresponds to financial years, and covers the period from April to March, targeting one dwelling per address and one household per dwelling, using the Royal Mail Postal Address File.

In the case of the housing survey, a smaller sample is involved, which in turn requires the data from two years to be pooled in order to obtain a sufficiently large dataset for the analyses based on it to be reliable; results are presented only for either even or odd years. The stratified sampling requires appropriate weighting of the data; data including gross

weights reflect nationally representative estimates. The EHS housing survey provides a range of information on housing conditions.

For the study, we selected 14 variables relevant to this particular type of analysis (see Table 1). Four of them are different types of housing tenure. The others are economic in nature and refer to the costs that households incur according to the type of tenure or indicate the percentage of these costs in the total household spending (taking HB into account). Yet another variable accounts for those who are either working and receiving housing benefit or not working and receiving such benefits. An important aspect of the study is to treat some variables separately for London and England excluding London. This is because these are competing markets which have quite different characteristics and dynamics, and between which there are undoubtedly some flows (in this sense, they are substitutive markets). Therefore, it is worth taking this phenomenon into account in the model. This is all the more important, as London itself and England excluding London are also separately captured in relation to most of the statistics released in the EHS survey [59].

**Table 1.** Variables used in the study.

Variable	Var (Code)
owning outright	OO
buying with mortgage	BWM
private renters	PR
all social renters	ASR
recent first-time buyers London	RFTBL
recent first-time buyers excl. London	RFTBEEL
mortgage payment London	MDMPL
mortgage payment excl. London	MDMPEEL
rent payment in London	PRMDWRL
rent payment excluding London	PRMDWREEL
mortgage as a proportion of income incl. HB—owner occupiers	OOMRAPHIIHB
rent payment as a prop. of income incl. HB—private renters	PRMRAPHIIHB
receipt of HB—private renters working	PRWFPT
receipt of HB—private renters not working	PRNW

As for the rationale of the inclusion of the aforementioned variables, it is relevant to point to Law and Meehan [63] who identify household income and mortgage interest rates as the most important determinants of housing affordability. In addition, important findings seem to come from a study by the Zillow Group [64], which addresses the relationship between rent payments and different forms of housing tenure [64]. The study shows, i.a., that the length of time one stays in a rented housing unit is inversely proportional to the likelihood of shifting from this form of housing tenure to home ownership. In quantitative terms, more than half of tenants who have been renting for five or more years are no longer interested in switching from renting to buying their own home. According to Bryx et al. [7], the encouragement of interest in home ownership should play an important role in housing policy. One way to achieve this is to raise people's awareness of this issue from an early age. Chi and Laquatra [65], on the other hand, highlight the problem of the much higher housing cost burden that renters face compared to homeowners, and that households with lower income spend a greater proportion of their income on housing expenses. Hence, the intensity of the cost burden related to renting will exert an influence on housing tenure choices. Given the substitutability of these markets and the close relationship between them, we include both weekly mortgage payments and weekly rent payments in the analysis. A larger share of housing costs as a share of income, including HB, may influence the related opinion [7].

It is worth noting that the EHS dataset is compiled between April and March (for a given year); therefore, EHS 2019–2020 does not yet reflect the COVID-19 pandemic, whose outbreak in Europe coincided with the final month of its timely processing (i.e., March of 2020). Full data covering the first year of the pandemic were captured in EHS 2020–2021, which entailed a change in the previously established survey mode [66]. The pandemic

made it necessary to replace face-to-face interviews with telephone interviews; internal inspections of properties were no longer carried out, and external inspections were used instead, along with a combination of administrative data sources.

The wording of some of the household interview questions was adapted to be asked on the telephone, and the physical survey was unable to collect some data items at all, e.g., information on the condition of the homes that relies on a surveyor's assessment of the inside of a home.

### 3.2. Characteristics of the British Housing Market and Housing Tenure Trends

In this section, we present the basic data on housing in the U.K., taken directly from the very large research surveys conducted as part of the cyclical EHS. We include these data in synthetic form in Appendix A in the form of Tables A1–A19. They provide an initial analysis and understanding of which variables are important for more meaningful inference based on the DAG model and Bayesian networks.

Table A1 shows that over the last 12 years (2008–2020), the number of owner occupiers has fallen by nearly 3.5%, and the number of private renters has increased by 4.5% over the same period. The difference between these two figures (statistics) is accounted for by a fall in the number of social renters of ca. 1%. Interestingly, while the number of owners fell quite significantly, when analysing the internal structure of this process, the reason for this phenomenon was largely due to the decline in the number of those who were buying with a mortgage (ca. 7%). This decrease was mitigated by the growing number of people who became owners of dwellings directly (without a loan, i.e., either by buying with cash or inheriting a dwelling or receiving a donation). Moreover, since 2013, the proportion of people who own their home outright has been higher than the proportion of those who pay a mortgage. It is also clear that with each passing year, it is becoming increasingly more difficult to receive housing from local authorities. However, the decreasing number of dwellings received from local authorities is partly compensated by the supply of dwellings allocated by housing associations. The activity of the latter in the context of housing allocations has offset almost half of the decline in the number of dwellings granted by local authorities (thanks to this, the number of social renters has fallen by only 1.1% instead of 2.2%).

Table A2 shows that the increase in the number of outright homeowners and the decrease in the number of homebuyers with mortgages is quite a complex phenomenon, and the heterogeneity in this context cannot be explained solely by the income and wealth of individual regions. The category “owning outright” as a form of tenure should not be understood here as purchasing a dwelling or a house, but only as owning a house/dwelling. Economic reasons, on the other hand, are more evident in the context of those buying with mortgage. For example, in the North East region, by far the poorest region of the U.K., there has been a 10.2% fall in the number of home buyers with mortgages over the last 12 years. This was the largest fall in this category across all regions. However, the second poorest region, East Meadlands, has not seen a decline of the same magnitude as the North East. Comparing all regions, the number of homebuyers with mortgage has fallen the least there, by 3.9%, which is even less than in the richest in terms of income and wealth London (which has seen a fall of 5%).

In fact, the U.K. housing market is very complex in its nature. First of all, it must be taken into account that it is subsidised via an income-related housing benefit calculated using the Local Housing Allowance [4].

Table A3 provides an insight into the demographic and economic structure of tenants. It shows that the representation of young people owning their own dwellings outright is very low (only 0.3%, 1.0% and 3.2% in the subsequent lowest age categories—16–24, 25–34, and 35–44, respectively). On the other hand, of those respondents who are homeowners outright, as many as 62.5% are seniors over the age of 65. These statistics paint a very worrying picture of the U.K. housing market, given that the overall number of people owning outright has been rising steadily for a number of years.

This shows that an increasing number of people are becoming priced out of housing markets, in the sense that they cannot afford to buy a home. Deng et al. [67] highlight that this phenomenon mainly affects young adults, for whom not only is buying a home no longer affordable, but now also renting is no longer achievable [68].

Table A4 shows that homeowners have almost no dependent children (92%). The situation is slightly different among those owner occupiers who bought their homes with mortgages. However, even in this category, homeowners without children predominate with a ratio of 55% to 45%. These statistics are relatively stable when viewed through the prism of the last 12 years. On the other hand, the number of private renters with family members has increased significantly in recent years. The percentage of all private renters has increased over the past 12 years from 29.8% to 36%.

Interestingly, the coronavirus pandemic has resulted in a marked increase in the percentage of home buyers outside London in 2020 (Table A5). While in 2018–2019, this percentage was 82.6%, the period 2019–2020 (and thus, including the pandemic) brought a substantial jump in this percentage to 86.8% (this is also the highest readout of this indicator over the last 20 years). The significant increase in the number of first buyers outside London (to a historic high) is in part due to faster growth in the mortgage payments specifically in London compared to England (excluding London). A comparison of the 2018–2019 and 2019–2020 periods clearly shows an increase in the average mortgage over the specified period of almost 7% in London (the median increased by 4%) and only 4.9% in England outside London (the median did not change) (Table A7). In a nutshell, those who buy with mortgage are priced out from the London's market. In this context, the trend of increasing interest in private renting also seems more understandable. Given that weekly rent payments have remained virtually unchanged over the reference period (rising from GBP 341 per week to GBP 342 per week in London alone, and even falling from GBP 162 to GBP 159 per week outside London), the renting market appears increasingly attractive from a purely economic perspective (Table A8).

When it comes to the structure of first-time home buyers, most of them are in the 25–34 age category (65.1%). In second place are those who fall into the 35–44 age category. In total, these two categories (25–44 years) account for 86.8% of all housing purchases. As for the economic structure of the buyers, these are people whose earnings significantly exceed the national median (the third, fourth and fifth quintiles account for 22.4%, 34.1%, and 28.0%, respectively). These statistics, therefore, show that over 60% of first-time buyers are those individuals whose incomes are represented by the fourth and fifth quintiles of households with the highest weekly income. Moreover, couples without children and single individuals account for nearly 65% of the total demand for new homes (Table A6).

For 45.7% of buyers with mortgages, the percentage of the purchase price paid (i.e., the down payment) is 10%–19%. For 25% of buyers, it is 25%. So overall, 70.7% of buyers with mortgages pay no more than 19% (as a down payment). Those who buy with cash account for only 6.9%. The English Housing Survey also shows the length of mortgage tenure (i.e., years to run on mortgage when taken out). In total, 48.8% of buyers intend to repay their mortgages within 20–29 years and only slightly less—46.9%—decide on a repayment period exceeding 30 years. For 85.3% of mortgage buyers, the source of financing of the deposit (own contribution) is savings, but it is worth noting that for 27.9% (these categories do not add up to 100% because they are not mutually exclusive), the source of financing is gifts or loans from family or friends. This, in a way, confirms the earlier research by Druta and Ronald [5], who studied housing affordability in the U.K. They found that worse price affordability means that young adults' entry into home ownership is now more frequently achieved through parental support, which takes the form of financial transfers (e.g., loans) or in-kind transfers. Some are also using funds they inherited from their family.

Interestingly, buyers predominantly choose to take out mortgages jointly with their partners (60.4% of all mortgage buyers), which is higher than the proportion of all couples occupying their homes jointly—58.2%, see Table A3). The average deposit is GBP 42,433



(median GBP 23,600), meaning most people buying a home cannot even afford the average deposit (the distribution describing this phenomenon is right skewed).

On the other hand, comparing mortgage/rent as a proportion of household income, one can also see that over the last 12 years, the difference between these proportions has been gradually converging (especially when taking into account housing benefit), which further strengthens the trend of growing interest in private renting (Table A9). It should be noted that in the examined period, the level of mortgage as a proportion of household income practically did not change, whereas the rent payments as a proportion of household income significantly decreased (from 43.7% to 36.65% when housing benefit is not taken into account) (Table A9). The increasingly better situation of private renters is manifested by the number and proportion of households in rent arrears (Table A10), which has systematically decreased over the last 12 years (from 10.9% to 7.6%).

However, with regard to housing benefit itself, it should be noted that only 20.3% of respondents who are private renters receive such support, while most of the funds are for social renters (56.4%; sample 2438 private renters and 3430 social renters). For those private renters and social renters who received such support, housing benefit in 2020 was GBP 113 and GBP 81 per week, respectively (Table A12). It is mainly given to private renters who do not work (51.2%), while of those who do work, only 11.2% received such support (Table A13).

It is also worth noting that mortgage borrowers have no particular difficulty in paying their mortgage obligations. In 2019–2020, 96.2% had no difficulty in meeting them. In contrast, 73% of private renters said it was very or fairly easy for them to pay their rent. This means that only 27% of tenants find it somewhat difficult to meet their rent obligations (Table A11).

The fact that someone decides to rent rather than buy a dwelling with a mortgage can partly be explained by the lack of savings among the vast majority of renters when compared to buyers with mortgages. To be more precise, 60.1% of renters have no savings at all, whereas in the case of buyers with mortgages, the situation is exactly the opposite, i.e., almost 60% (59.7% to be precise) declare having some savings.

Interestingly, 59.5% of private renters intend to buy their own dwelling, of which 26.7% are no later than within 2 years, and over 60% of renters intend to buy their own dwelling within the next 5 years (Table A14). However, these latter statistics remain virtually unchanged throughout the period under study (the last 12 years), and yet the number of renters is increasing year by year (Table A15).

Table A16 shows that for private renters, the average number of years in current home is 4.3 years. Interestingly, looking over the last 12 years, this number has been slowly but steadily rising (from 3.7 in 2008–2009 to 4.2 in 2019–2020). This means that they are getting more and more used to renting.

Table A17 shows previous tenure by current tenure. Interestingly, 68.2% of those who own outright have also previously owned outright, and 19.5% have become owners by repaying their mortgage loan. In contrast, 43.1% of those who previously rented are now living in a dwelling bought with a mortgage, and 7.9% of those who previously rented have swapped renting for owning outright. In other words, as much as 51% of all owner-occupiers surveyed declared that they had previously rented a dwelling.

Table A18 shows that the highest life satisfaction, as well as the perception that life is worth living, is found among respondents who own their homes. In this context, it does not even matter whether a person bought his/her home outright or financed it with a mortgage.

The same proportion of respondents (who owned their home or bought it with a mortgage) indicated that life was worthwhile for them, and although in terms of life satisfaction, respondents who financed their purchases with mortgages indicated lower levels of life satisfaction, the difference was not as significant as for those who were private renters. On the other hand, those who own outright are more likely to feel lonely (partly because the dwellings they own are underoccupied). As for the outright homeowners,

5% of them indicated that they feel lonely (often or permanently). In turn, for private renters, this problem is not as pronounced since only 3.1% of them reported feeling lonely (Table A19).

### 3.3. Bayesian Network and Directional Acyclic Graphs

Having discussed the research framework of the paper, the theoretical background and the characteristics of the British housing market and prevailing housing tenure trends, we proceed to discuss the research methodology used in this study, namely the Bayesian network (BN) model. In short, BN is an efficient and powerful method to analyse the conditional dependencies of a set of variables. It can also be viewed as a graphical model that represents a set of variables and their conditional dependencies, using a directed acyclic graph (DAG). The Bayesian network was first proposed by Pearl [10,69] in the 1980s. More importantly, Pearl [69] further extended their use to artificial intelligence systems (the so-called expert systems), so that BN is now a popular method for making inferences based on complex data sets (wherever uncertain knowledge is involved). In other words, BN allows for a better understanding of relatively complex phenomena. In this sense, it provides an appropriate framework, reflecting probabilistic relationships among multiple variables, and appropriately instrumentalising research hypotheses and quantifying supporting evidence [70]. For example, Constantinou and Fenton [71] relied on a Bayesian network model to assess the prospective performance of investment in the London buy-to-let property market, from an investor's perspective, and to examine the impact of tax reforms. Ozdamar and Giovanis [72] used BN to explore the causal effects of housing benefits and household income (and income support) on the subjective mental well-being in the United Kingdom (U.K.). Papakosta et al. [73] made a probabilistic prediction of wildfire economic losses to housing using Bayesian network analysis. Wang et al. [74] used Bayesian network to analyse the results of a questionnaire survey (Housing Survey Questionnaire) addressing housing demand preferences among different social groups. These are only a few examples of which there are many more.

A Bayesian network can also be viewed as a probabilistic graphical model representing a set of variables and their conditional dependencies (directed acyclic graph, DAG). Bayesian networks are ideal for predicting from an event that has occurred the probability that one of several possible known causes was the contributing factor. Generalisations of Bayesian networks that can represent and solve decision problems under uncertainty are called influence diagrams.

From a technical perspective, any BN model can be represented graphically as a DAG for which the individual nodes are variables in the Bayesian sense. Moreover, these variables are not necessarily observable. They may also take the form of latent variables, or even hypotheses (or unknown parameters). Conditional relationships are represented by edges. On the other hand, the fact that there is no connection between nodes (no path connects such nodes to each other) proves that there is no conditional link between the variables that are represented by these nodes. The individual nodes can be defined by an appropriate probability function, which on the input uses (as arguments) a specific set of node's parent variables (which take certain values), while on the output, it generates the system's output data as well as the probabilities with appropriate distributions (as the case may be) for specific nodes (represented by appropriate variables).

#### Bayesian Networks (BNs): An Overview

Bayesian networks are used for diagnosing real world problems and making predictions. It allows inferences to be made with respect to uncertain knowledge [75,76]. Moreover, it works very well in visualising probabilistic relationships between multiple variables [76]. Among many advantages of this analytical method, the most frequently mentioned are the ability to deal with incomplete and small data sets, linking multiple sources of information, structural learning, addressing uncertainty in a tractable way, providing quick answers/solutions and, in this context, being an effective tool to facilitate

the decision-making process [77]. Typically, a Bayesian network comprises a qualitative part [78], i.e., structural learning, graphically (as a directed acyclic graph—DAG) reflecting the relationships between variables, and a quantitative part addressing the conditional dependencies between variables in the context of their joint conditional probability distributions; the quantitative part is otherwise referred to as parameter learning. DAGs have gained popularity as an important tool in such disciplines as machine learning and artificial intelligence. One of the most recent applications of DAGs is their use as a structuring tool in cryptocurrencies.

A visualisation of a Bayesian network taking the form of a directed acyclic graph reflects probabilistic variables through nodes and causal relationships between these variables by arrows (arcs). A node that has no inward arrow is called a parent node, while those that have inward arrows are referred to as child nodes. In order to perform the relevant calculations and parametrise the model, the states of the individual nodes must be properly defined, and their probabilities must also be specified. In the Bayesian statistical inference, causal relationships between variables are modelled with the Bayes' theorem, which addresses the likelihood of an event based on the prior knowledge of its conditions [79–81]. In other words, BN is based on conditional probabilities,  $P(A | B) = \frac{P(B|A)P(A)}{P(B)}$ , which allows to come up with an inverse probability. For the sake of argument, let us suppose that before any relevant evidence with respect to a certain event  $A$  is observed, its probability of occurrence can be referred to as the initial probability  $P(A)$  (in the Bayesian nomenclature, it is called a prior). In turn, the probability  $P(B|A)$  expresses our belief about an event  $B$  in the context of our knowledge with regards to  $A$ . If  $B$  is observed, then by multiplying the prior probability  $P(A)$  by the probability  $P(B|A)$  and normalising the result by dividing it by the constant  $P(B)$ , we obtain the adjusted posterior probability  $P(A|B)$ . By performing a certain transformation of the above expression, we obtain  $P(B|A) = \frac{P(A|B)P(B)}{P(A)}$ , which can be used for predicting the knowledge about  $B$  (which is not yet observed).

Thanks to such a structure of interrelationships, we have a suitable approach for modelling and analysing dependencies between variables. Moreover, at least several important advantages can be distinguished in this kind of research method [82]. Namely, (1) BNs are characterised by high flexibility in the selection of input data and generation of output results; (2) from the perspective of the system input, it is possible to take certain values of known variables, and at the output of the system, it allows to assess the probability of a given variable; (3) BNs allow to update diagnoses or predictions before and after the introduction of evidence; (4) the calibration of the BN model does not require historical data (expert opinions can be used for this purpose); (5) changes in the network that affect individual variables and their observations can be isolated, and in this sense, they can be updated without significantly affecting the rest of the whole network; (6) thanks to the graphical representation, this method allows the relationships between variables in the process to be appropriately diagnosed and analysed; and (7) this method is used for sensitivity analyses whereby predictions or certain conclusions regarding future events can be made in relation to certain initial assumptions. In other words, it allows to understand the degree to which a given node influences other nodes (greater influence of a given node on other nodes is reflected by greater entropy, which is a representation of the sensitivity in this context).

Creating BN models and performing dispersion calculations are done in R-4.1.1 software thanks to the `blearn` and `Rgraphviz` packages, which provide fast propagation for networks that can involve up to hundreds of variables for which they come up with appropriate probability and distribution graphs.

In order to define Bayesian networks (BNs) it is necessary to determine (1) the structure of the network, which takes the form of a directed acyclic graph  $G = (V, A)$ ; in a given BN, each random variable  $X_i$  is represented by a specific node  $v_i \in V$  (although variables do not necessarily have to be observable), and (2) the probability distribution of  $X$ , which is characterised by specific parameters  $\Theta$ . According to the arcs  $a_{ij} \in A$  in a DAG, such a global distribution can be factorised, which allows to determine smaller local probability

distributions. This factorisation of the global distribution in the DAG model (which can be expressed as:  $P(X) = \prod_{i=1}^N P(X_i | \Pi_{X_i}; \Theta_{X_i})$ , where  $\Pi_{X_i} = \{\text{parent of } X_i\}$ ) provides a graphical separation that shows the conditional dependency relationships between variables (such as the role of the Bayesian network structure).

Set out below are the strengths of the Bayesian networks method with particular emphasis on their superiority (advantages) over other alternative research approaches [83]:

- Unlike other statistical methods, BNs address the problem of uncertainty in a transparent and explicit manner;
- It allows causal factors to be modelled, which makes it useful for forecasting and predicting the future;
- BNs are powerful tools for visualisation and therefore also for communication. In this respect, they can be seen as an approach that is suitable for conceptualisation, and is intuitive and understandable;
- It reflects in a simple way the mutual causal relationships between nodes (under which are hidden observable or latent variables, or even hypotheses);
- Causal relationships between variables or nodes can be easily seen without the need to calculate probabilities;
- Predictions of future events with this method do not necessarily have to be based on complete data; in the absence of specific observations, the model may rely on prior distributions;
- BNs prove useful in the development of models describing complex systems;
- Both objective and subjective data, e.g., opinions of experts, can be included in a BN model. This feature of BN models should be considered their great advantage, especially considering that the availability of objective data is usually limited, and in this sense, such data are scarce. On the other hand, in the absence of objective data, some subjective data can always be generated;
- The inference runs from an effect to a cause and vice versa. In this context, each time a relevant observation is introduced into any node of the Bayesian network, the probability distribution for the unknown variable is also updated accordingly;
- The beliefs on which a model is founded can be updated or changed relatively easily, which is useful when new evidence emerges;
- It is used for sensitivity analyses whereby predictions or certain conclusions regarding future events can be made in relation to a number of initial assumptions.

#### 4. Results

The data conditional dependencies (network structure) are learned with the use of the incremental association Markov blanket (IAMB) algorithm [84,85]. To perform an inference about a random variable based on a certain set of variables, usually a subset is sufficient for this, and other variables are useless. In this regard, the Markov blanket can be understood as such a subset that contains all the useful information. When having at disposal a certain set of variables, in order to make an inference about a particular variable, there is no need to use the whole set for that. Not all variables are useful for making such an inference about a variable. Typically, only a certain subset will suffice for this. By removing from the full set of variables those useless for making an inference (leaving only the useful ones), the subset that is left (as a remainder) is defined as a Markov blanket. There is also such a notion as a Markov boundary, or otherwise a minimal Markov blanket, which is one for which no additional variable can be dropped without losing information that is required to perform the inference. Both concepts are functional in the context of extracting some useful features.

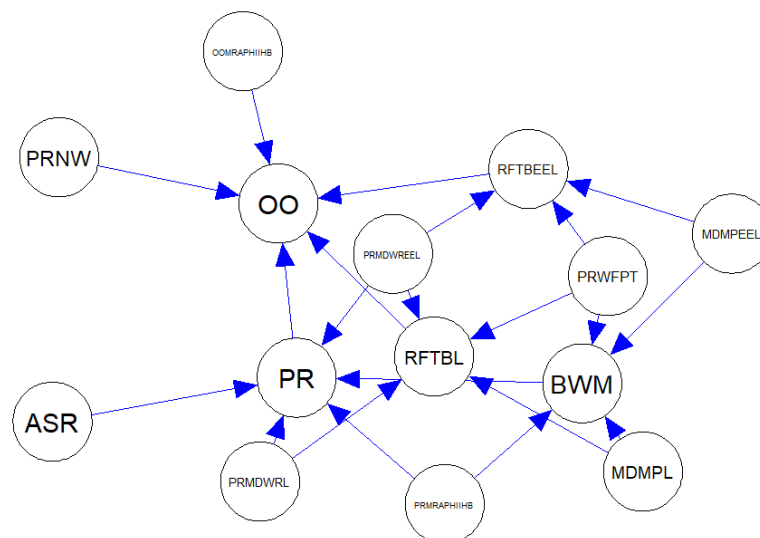
The IAMB algorithm addresses the internal states and external states that form a certain system. In this context, the Markov blanket defines the boundaries of this system and allows to perform its statistical partition separating the two states. The analysis is performed in R-Studio, using the bnlearn and Rgraphviz packages.

Table 2 shows that all arcs of our model are directed, and the average Markov blanket size is 7.29. In this sense, the model meets certain minimal assumptions that allow it to be treated as a DAG. It is also important that the number of undirected arcs is zero, meaning that the IAMB algorithm was able to set the orientation of all arcs.

**Table 2.** BN model established with the use of IAMB algorithm.

nodes:	14
arcs:	21
undirected arcs:	0
directed arcs:	21
average Markov blanket size:	7.29
average neighbourhood size:	3
average branching factor:	1.5
learning algorithm:	IAMB
conditional independence test:	Pearson's correlation
alpha threshold:	0.05
tests used in the learning procedure:	380

In the next step, the conditional dependencies (network structure) are shown in the form of a directional acyclic graph, which allows a visual assessment of the dependencies between the variables under study (Figure 1). Firstly, note that a node is never part of its own Markov blanket. For a DAG  $G$ , in which  $V$  denotes the set of its all nodes, and  $v$  is an individual node (hence  $v \in V$ ), its local distributions are determined in terms of the single node  $v$  and its parent node  $u$  (assuming that  $u \neq v$ , and  $u \rightarrow v$ , which can be expressed as  $pa(v)$ ). Consequently,  $p(x) = \prod_{v \in V} p(x_v | x_{pa(v)})$  reflects the overall joint density, and it allows for making local computations for individual tasks, irrespective of the size of  $|V| = n$ , relying only on a few variables at a time. The appropriate use of local computation is made possible through the Markov blanket described above [69,84,85], which is the smallest set of nodes  $Mb(v)$  for which no additional node  $v$  can be dropped without losing relevant information required to perform the inference. In this regards,  $Mb(v)$  separates  $v$  from all other nodes which can be expressed as  $V \setminus \{v, Mb(v)\}$ . It is worth noting that the Markov blanket constitutes an important notion in the BN method, as it forms the basis of the Bayesian network learning algorithm and allows the selection of variables for classification, as well as finding causal relationships [84,85].



**Figure 1.** Directed acyclic graph (DAG) addressing the conditional dependencies of an extensive set of EHS variables.



The probabilistic relationships reflected by the arcs of the Bayesian network can be measured in terms of their strength, and model averaging can be used to build a network containing only the significant arcs.

Probabilities of inclusion of all possible arcs and their directions are shown in Table 3. We take into account only those whose strength is greater than 0.5.

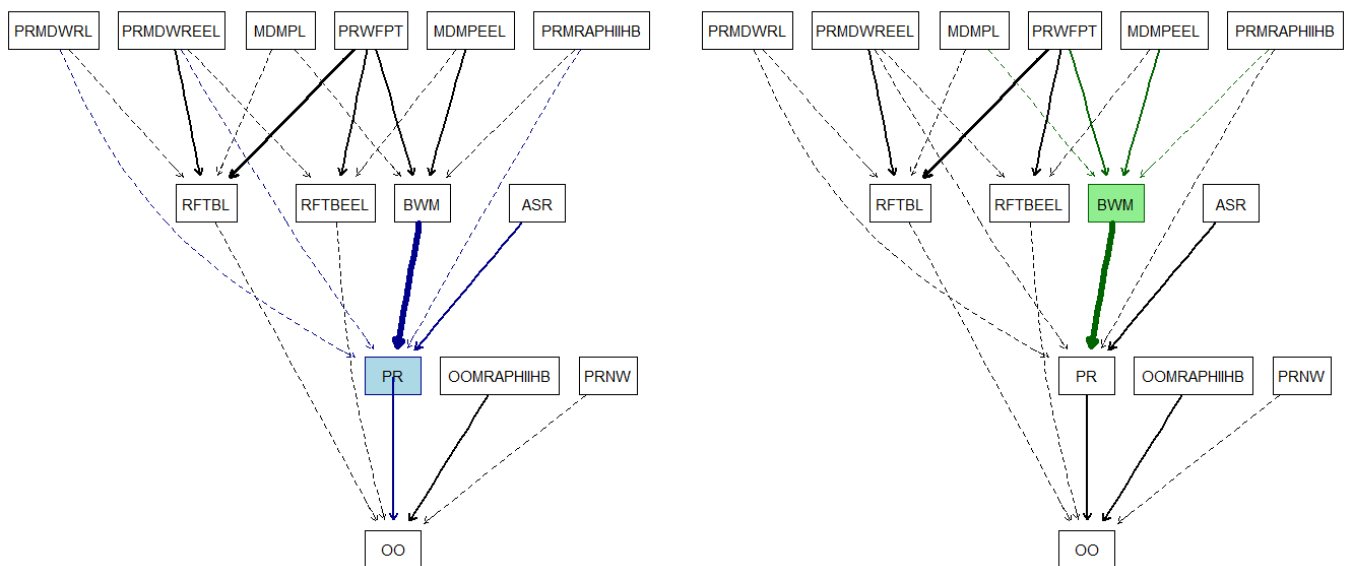
**Table 3.** Probabilities of inclusion of all possible arcs and their directions.

	From	To	Strength	Direction
2	OO	PR	0.655	0.8702290
8	OO	PRMDWRL	0.775	0.2193548
9	OO	PRMDWREEL	0.86	0.7093023
15	BWM	PR	0.975	0.8794872
20	BWM	MDMPEEL	0.605	0.5661157
27	PR	OO	0.655	0.1297710
28	PR	BWM	0.975	0.1205128
29	PR	ASR	0.64	0.1054688
42	ASR	PR	0.64	0.8945312
49	ASR	OOMRAPHIIIHB	0.63	0.5158730
50	ASR	PRMRAPHIIIHB	0.705	0.6631206
63	RFTBL	PRMRAPHIIIHB	0.625	0.6200000
64	RFTBL	PRWFPT	0.71	0.5070423
86	MDMPL	PRMDWRL	0.805	0.2360248
87	MDMPL	PRMDWREEL	0.64	0.3984375
89	MDMPL	PRMRAPHIIIHB	0.64	0.4453125
93	MDMPEEL	BWM	0.605	0.4338843
99	MDMPEEL	PRMDWRL	0.98	0.6403061
105	PRMDWRL	OO	0.775	0.7806452
111	PRMDWRL	MDMPL	0.805	0.7639752
112	PRMDWRL	MDMPEEL	0.98	0.3596939
118	PRMDWREEL	OO	0.86	0.2906977
124	PRMDWREEL	MDMPL	0.64	0.6015625
134	OOMRAPHIIIHB	ASR	0.63	0.4841270
147	PRMRAPHIIIHB	ASR	0.705	0.3368794
148	PRMRAPHIIIHB	RFTBL	0.625	0.3800000
150	PRMRAPHIIIHB	MDMPL	0.64	0.5546875
155	PRMRAPHIIIHB	PRWFPT	0.695	0.4928058
161	PRWFPT	RFTBL	0.71	0.4929577
168	PRWFPT	PRMRAPHIIIHB	0.695	0.5071942

On the basis of the previous analysis, which is presented in Section 3.2, we have selected 14 variables that may be relevant for a more advanced analysis in the form of Bayesian networks. It can be concluded that it is the substitutability of the variables “private renters” and “buying with mortgage” that presents the greatest significance for understanding the relationships prevailing in this market. The nature of the data structure and conditional dependencies between variables is evidenced by the thickness of the arrows (Figure 2).

When all the edges between different variables are oriented, it is possible to fit the model and parameterise its edges.

Directional acyclicity of the model allows for appropriate parameterisation, which in turn allows for a quantitative understanding of the prevailing relationships between variables under study (Tables 4 and 5).



**Figure 2.** DAG showing in more detail the nature of the relationships between the variables included in the study.

**Table 4.** Parameters of node “buying with mortgage” (Gaussian distribution; conditional density).

Coefficients:	
MDMPL	−0.1254274
MDMPEEL	0.1300662
PRMRAPHIHB	−0.3402907
PRWFPT	−0.3337033
(Intercept)	54.5290877
Standard deviation of the residuals:	1.0058540

**Table 5.** Parameters of node “private renters” (Gaussian distribution; conditional density).

Coefficients:	
BWM	−0.9469600
ASR	−0.6772966
PRMDWRL	−0.0131658
PRMDWREEL	−0.0825447
PRMRAPHIHB	−0.0472975
(Intercept)	75.8070732
Standard deviation of the residuals:	0.2700468

After appropriate parameterisation of the model, we obtain coefficients for individual nodes, which in fact can be interpreted as  $\beta$  coefficients in classical multivariate regression models. In fact, these coefficients quantitatively describe the strength and direction of the relationship between the variables. In the case of the study on which we base the inference in this article, the parameterised nodes (Tables 4 and 5) describe the impact of the individual variables included in these tables on the variables “buying with mortgage” and “private renters”, respectively. A more detailed discussion of the results is conducted in the subsequent (Discussion) section.

## 5. Discussion

Firstly, the theoretical section highlights the importance of private ownership (owner-occupied housing) so as to ensure a well-functioning society. This also implies greater life satisfaction which is also indicated by the results of the EHS survey (Table A18). In a way, the results of this study support the earlier findings presented by Zumbro [23]. Moreover, a

society that lives in PRS is a society with a number of social problems, e.g., related to higher public spending on social and health care [2].

The growing significance of the PRS in U.K. is not the result of a changing social preference for private renting. This was shown in the study conducted by Rugg and Rhodes [2]. In this context, this study also shows that housing benefits do not necessarily facilitate private renters' path to their own home. HB has, in fact, been criticised by other researchers [2,4,86,87]. Cole et al. [87] criticise HB for new rules of its calculation (extending the age threshold from 25 to 35 at which the shared accommodation rate of benefit payment is applied) that resulted in a decrease in HB received by single people living in self-contained housing. Clair [4], on the other hand, criticises it for the fact that changes in HB (calculated on the basis of LHA, in order to reduce government spending) resulted in a 5% increase in overcrowding among housing benefit recipients following changes in the local housing allowance (roughly equivalent to 75,000 households). Clair [4] also highlights the disconnection between HB and actual rent payments, which thereby significantly reduces the ability of recipients to access adequate housing and clearly has implications for health and wellbeing; this becomes even more important during the COVID-19 pandemic. In this context, Simcock [88] points out that nearly 3 million tenant households in the U.K. are just one paycheque away from losing their homes, with private renters having to spend a higher proportion of their income on housing costs compared to other forms of tenure. The latest English Housing Survey shows that private renters spend 45% of their income on rent, while owner-occupiers only have to spend 19% on a mortgage, and the majority of renters have no savings. The country is currently in a state of limbo as many people have lost their jobs and income, leaving many tenants with significant rent debts and having to apply for welfare [88].

It must be stressed that there are no obvious solutions. On the one hand, promoting ownership is good. However, buying a dwelling with a mortgage implies a commitment for many years and is a decision that is not detached from market conditions. Changes in the latter can have serious financial consequences for individuals taking out such loans. Therefore, promoting buying with a mortgage in the current market conditions is not completely reasonable and prudent.

Viewed in general terms, the logic of promoting mortgaged ownership would no longer hold if interest rates start to rise again. This would probably bring a fall in housing prices and strong political repercussions over time; for years, the idea of home ownership has been sold to young people as something important. Young people would not be happy to see the value of their assets, into which they put their hard-earned savings in the form of deposits, fall. If we assume that a series of interest-rate hikes are ahead of us (the direction is set by the American FED, which has already signalled a series of increases at its FOMC meeting in January of 2022; other countries have already tightened their monetary policies, including the U.K., where the Bank of England hiked the main interest rate from 0.1% to 0.25% in mid-December 2021—for instance, in Poland, there have already been four increases, and the reference interest rate increased from 0.1% to 2.25%), we cannot rule out a drop in housing prices, all the more so as some buyers may have accelerated their housing purchase decisions in 2020–2021 and bought earlier than they had intended before the pandemic (fearing inflation and higher prices). So some of the demand that was planned for 2022–2025 could have been realised earlier (in the form of an inverse pent-up demand). If so, no one should be persuaded to ownership at all costs (in view of the risk of falling prices). In the long term, however, the state should support home buyers, and create mechanisms that facilitate access to mortgages (with built-in hedging instruments against variable loan instalments). Government spending should be aimed at building a system to promote ownership based on secured mortgages so that at least part of the risk (of a potential fall in housing prices) is taken off the shoulders of potential buyers, who are often poor people. In this way, the state would stabilise the price market (through increased purchases), support the banking sector, and reverse the negative trends in the

housing tenure structure. In a similar context, Guren et al. [49] wrote about mortgage finance systems, stressing the need for mortgage borrowers to have repayment flexibility.

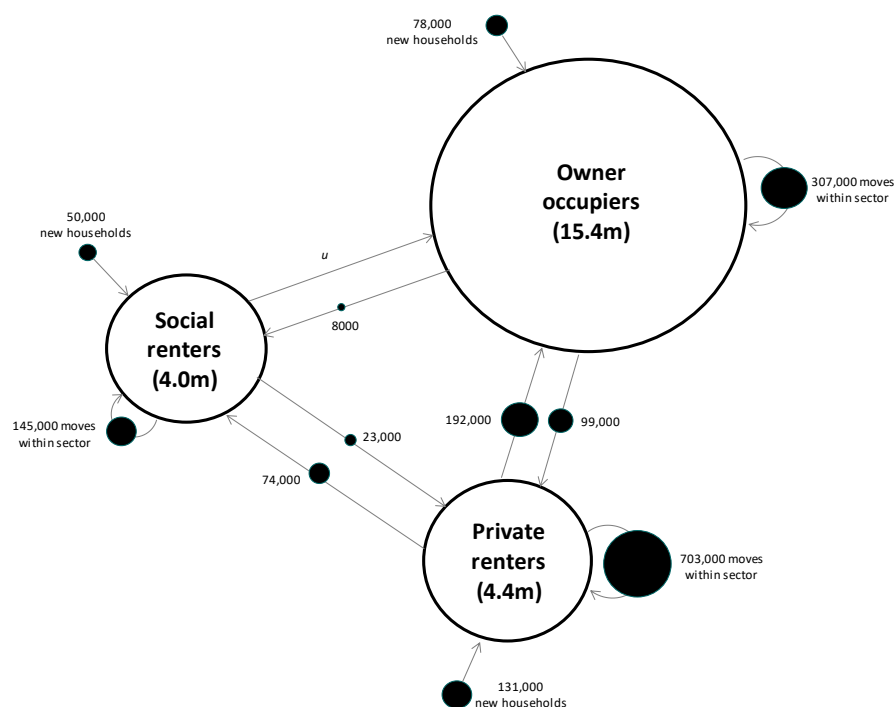
Mulheirn [1] also highlights that when the trend in FTB lending was normalised (and the rate of FTB lending returned to its normal rate), this caused the home ownership rate to stabilise and begin to return to normal. This confirms that financialisation is an extremely important element that can halt the shift in housing tenure towards PRS (supporting buyers with mortgages).

Financial risk is evidenced by high home ownership rates coupled with very high price-to-income levels as a result of mortgages with very high loan-to-value (LTV). This is the case when deposit requirements (own contributions) are low. Mulheirn [1] points out that in the case of FTBs, the median LTV ratio is around 85% with the average being about 10% lower, i.e., around 75%. The 10-percentage-point difference in this case indicates that the requirements are much higher for smaller borrowers (in terms of loan value). LTV should be understood in such a way that 100% LTV would mean granting a loan without any own contribution. This would, for obvious reasons, shift the risk towards creditors. On the other hand, in this phase of the housing boom cycle, mortgage lenders cannot accept too much risk on their balance sheets.

The results show that, depending on the location (either London or England excluding London), an increase in mortgage payments can interact negatively (in London) or positively (in England excluding London) with the buying-with-mortgage variable. Arguably, the reason for this is that the elasticity of demand varies across different locations in terms of changes in the cost of buying a dwelling with a mortgage loan. As is well known, house prices in London are significantly more expensive than in other regions, and mortgage payments are also significantly higher there when compared with other regions of England. This is clearly indicated by the EHS data (Table A7). The difference in median weekly mortgage payments between London and England excluding London was 48.33% in 2019–2020. In this context, for many potential buyers, the option to buy outside London may be the only one possible. It is also important to remember that house prices in London are significantly higher compared to other parts of England and, as a result, the deposit/own contribution that is required is also higher there. Any further change in the amount of mortgage payments in London may discourage potential buyers. It can also be viewed in terms of the flow of potential buyers between different regions. Rugg and Rhodes [2] point out the unique nature of the London housing market, which overshadows many of the debates about housing tenure in the U.K. (they refer specifically to the PRS). They also suggest the need for specific policy solutions. They argue that in terms of different housing tenure, London problems are often extrapolated to other regions of England. For example, in the U.K., 80% of migrants from other countries live in the PRS, with London having a much higher proportion of migrants compared to other parts of England. In general, the London market stands out in narratives of housing tenure [2]. Different housing tenure have different configurations in particular types of areas. Therefore, since the problems are not the same, the solutions should also take these differences into account.

In contrast, the significantly lower costs associated with both mortgage payments and dwelling purchases in other regions of England (taking into account housing affordability) lead to more mortgage buyers appearing there; it is reasonable to assume that buyers are advancing their purchase decisions, fearing further increases in mortgage payments. For example, Table A15 shows that the number of private renters declaring that they want to buy a dwelling increased between the 2018–2019 and 2019–2020 survey periods, from 55.80% to 59.50%. Table A14 shows that 61.5% of private renters intend to buy a dwelling within the next 5 years and 38.5% intend to buy a dwelling in 5 years or more. It can be assumed that each potential buyer revisits his/her purchase plans under the influence of significant economic factors. This certainly includes the increase in mortgage payments. In turn, the variable weekly rent payment as a proportion of income including HB has a negative effect on the buying-with-mortgage variable. This result is self-explanatory. Table A17 and Figure 3 illustrate previous tenure by current tenure (or household moves

by tenure) (2019–2020). They show that the vast majority of those buying with mortgage come from the group of private renters.



**Figure 3.** Household moves, by tenure (EHS data), 2019–2020. Note: The number of households, moved out or moved in within each housing tenure in 12 months is reflected by appropriate arrows and numbers. The total number of households in a given housing tenure (for the survey period covering 2019–2020) is shown in the circles. Figure 3 addresses only those households that changed housing tenure during the period under consideration ( $u$  indicates that the sample size is too small to make a reliable estimate).

As many as 43.1% of mortgage buyers declare that renting was their previous tenure. Table A14 shows that 59.5% of private renters declare (2019–2020) that they intend to buy their own dwelling with mortgage. When their financial situation deteriorates (either as a result of an increase in weekly rent payments or the loss of housing benefit), on the one hand, they perpetuate a psychological sense of financial vulnerability (discouraging them from buying); on the other hand, they are left with fewer resources, allowing them to save for their own contribution and a reserve for mortgage loan service. This is in line with the findings from the study conducted by Sitek [89], who provided evidence highlighting the importance of own contribution when taking out housing loans. Namely, in the vast majority of granted mortgages, the level of own contribution exceeded 20% of the value of the acquired real estate. Sitek’s study [89] points to the widespread problem of insufficient own contributions in the case of many potential borrowers, which obviously hinders the purchase of one’s own home (with mortgages) and thus translates into the decision-making process regarding the choice of housing tenure preferences. In the context of the U.K. market, the problem of impeded access to mortgage lending as a factor blocking access to own homes by first-time buyers is well described by Mulheirn [1]. One of Mulheirn’s observations is that when the trend in FTB lending was normalised (and the rate of FTB lending returned to its normal rate), this caused the home ownership rate to stabilise and begin to return to normal. This confirms that financialisation is an extremely important element that can halt the shift in housing tenure towards PRS private renting (supporting purchases from mortgages).

In contrast, the increasing number of private renters working and receiving HB has a negative effect on the “buying with mortgage” variable. This means that the policy of supporting private renters discourages them from buying their own homes with mortgages.



The results of the second model (Table 5) show that an increasing number of those buying with mortgages and all social renters negatively affects the number of private renters. In this sense, the negative relationship between buying with mortgages and private renters confirms the inference of the first model. In addition, the DAG model indicates that it is the “private renters” and “buying with mortgage” markets that are most closely related with each other. The results also indicate that an increase in rent payments (both in London and in England excluding London) translates negatively into the number of private renters. However, it is private renters in England excluding London who are more sensitive to weekly rent payment increases. However, on the other hand, they are less sensitive to increases in mortgage payments in the context of buying with a mortgage. This should come as no surprise, given that the U.K. market is largely a migrant market, with 35% of all migrants staying in the U.K. coming to London, as is highlighted by Vargas-Silva and Rienzo [36]. This in turn makes this housing market gravitate towards the PRS, since according to Rugg and Rhodes, 80% of all migrants are renters [2]. In other words, due to the large number of migrants (approximately 3,317,000) [36] the London housing market is PRS-oriented. On the other hand, migrants either do not want to buy housing (they assume a return to their country of origin) or simply cannot because they do not have the necessary creditworthiness. Either way, being constrained to renting, they have a higher tolerance for changes in weekly rent payments. In this context, it is also worth recalling the study by Malmendier and Steiny [22], which showed that migrants follow their previous macroeconomic experiences from their countries of origin. This may influence their specific preferences, i.e., those who have experienced inflation may nevertheless be interested in buying, but still the percentage interested in buying with a mortgage will be many times smaller as those opposed to renting.

Additionally, it should also come as no surprise that increases in rent payments as a proportion of income (including HB) negatively affect the number of private renters. On the other hand, we know from earlier analysis that an increase in rent payment as a proportion of household income (including HB) also negatively affects the number of buyers with mortgages (despite the substitutability of the two markets). This is evidence that the situation of private renters is difficult. In fact, their best chance of changing tenure into owner occupiers is by increasing their income, and not by receiving HB. In a sense, this confirms an earlier study by Filandri and Bertolini [27], who provided evidence of a negative relationship between state benefits and home-ownership levels. The inference that HB hinders the path to own housing is also confirmed by the EHS statistics (Table A16), showing the average number of years in the current home (by tenure). Over the last 12 years, this measure has increased significantly in the case of private renters (from 3.7 to 4.3). Bearing in mind that the longer someone rents a dwelling, the more likely he/she is to stay put [7,64], this may mean that fewer private renters will manage to work their way into their own homes in the future.

## 6. Limitations

It is also relevant to point out some limitations of the BN method. Firstly, like many other research methods, it is subject to human bias; formerly Bayesian networks were constructed on the basis of a heuristic algorithm, i.e., finding some approximate solution to an optimisation problem (based on human heuristics). The representation of reality that can be explained by the BN model to a large extent reflects the researcher’s perception of the issue under investigation. Secondly, model-based inference depends on making certain initial assumptions (so-called priors). Hence, the accuracy of BN models is the result of certain prior knowledge and the reliability of assumed beliefs of the researcher. Thus, when the prior beliefs deviate from the truth (are either too optimistic or too pessimistic), the whole network will also be distorted, and the results will not be reliable.

The discretionary choice of variables (some may perhaps criticise that their number is small as for the BN method) to describe such a complex housing market as the U.K. one can be seen as a limitation. We chose 14 variables (although we did not want to overcomplicate

the relationships to avoid problems with inference). It is possible to combine this type of research with other economic variables that are not covered in the EHS database, referring, for example, to the labour market, interest rates, LTV or LTI indices, or even migration data, which are quite important for the British market. It can therefore be concluded that the scope of the research, in terms of the possibilities of the research method we used, is relatively narrow.

Moreover, the main limitations of the data retrieved from the EHS database relate to estimates of rental patterns at sub-national levels: at least, this is the caveat set out by MHCLG [59]. To put this into perspective, data on ownership structure at the local authority level, derived from a range of survey, administrative and census data, were used to produce estimates of these sub-national estimates. Some data are based on a sample and are therefore less accurate than a comprehensive survey covering all individuals. Consequently, there is a margin of error associated with these estimates. It must be taken into account that for some local authorities and property categories, this margin of error can be considerable. As a general rule, the margin of error associated with these estimates increases as the variability in the estimates of tenure across different datasets increases.

## 7. Conclusions

In this paper, we rely on longitudinal EHS data (2008–2009 to 2019–2020) and Bayesian networks to analyse the flows between different forms of tenure in the U.K. More specifically, we conduct an analysis of the conditional dependencies of an extensive set of EHS variables through a directed acyclic graph (DAG). The study raises some of the issues and challenges of the contemporary housing market in the UK, and in particular, it explores what affects private renters and those buying with mortgages, considering these groups to be substitutive in nature. An important finding of this study is that housing benefits do not necessarily facilitate private renters' path to their own home. The study is of a quantitative nature with the use of the English Housing Survey and Bayesian network (BN) analysis that employs the IAMB algorithm.

The classical approach to modelling the relationship between observed variables is based on regression analysis and the division of variables into explanatory and response variables. The former are placed on the right side of the equation, whereas the latter are on the left side. The reality, however, may be much more complex than that which can easily be described by regression models. Relationships between variables can form a complex network of interactions. More comprehensive models, such as Bayesian networks, are used to model these interactions and to test the fit of the resulting interaction networks. The advantage of such models is the possibility to verify conditional dependencies between variables and to test hypotheses about the direction of such dependencies.

A future line of research could take into account, for example, the role of migrants in explaining the flows between different housing tenures (in this context, the BN method allows to include expert opinions). The U.K. housing market is extremely complex, so some explanation must also be sought in other variables that are beyond the scope of the EHS database. The direction with the use of machine learning methods (and BN specifically) seems to be the right one since it is the learning algorithm itself that analyses different iterations between variables and finds the most appropriate relationships between them. On the other hand, in the case of traditional methods, such as multiple regression or panel regression, it is up to the researcher to decide which type of relationship between the variables to choose. In this context, it is easy to disregard those relationships that actually exist in reality.

**Author Contributions:** Conceptualisation, J.S.; methodology, D.M.; validation, J.S. and D.M.; investigation, J.S. and D.M.; resources, J.S. and D.M.; data curation, J.S. and D.M.; writing—original draft preparation, J.S. and D.M.; writing—review and editing J.S. and D.M.; visualisation, D.M.; supervision, J.S. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

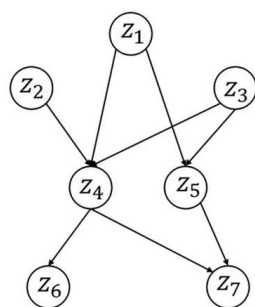
## Appendix A

### *Bayesian Networks (BNs) and Directional Acyclic Graphs (DAGs)*

BN is one of the four well-known methods of machine learning [8,9]. The other three include artificial neural networks (ANN), support vector machines (SVM) and a method that has evolved relatively recently, which is known as deep learning (DL). More specifically, machine learning uses advanced learning algorithms that are almost as good as humans at learning, and thanks to the increasing availability and ubiquity of large amounts of data, they are replacing humans more and more often for analysing complex issues.

According to Lv et al. [8], learning algorithms (which include the BN method) perform almost as well as humans due to pervasive data availability. In addition, it is not that these methods have suddenly appeared recently; rather, they simply were not as popular before because the massive datasets that are abundant these days did not exist back in the day. Additionally, computers did not have as powerful computing powers in the past as they do today, so BN remained a model that only allowed for the conceptualisation of certain scientific problems.

The Figure A1 below shows a Bayesian network [10] in the form of a directed acyclic graph with seven variables, which are represented in the figure as nodes  $\{z_1, z_2, \dots, z_7\}$  (propositional variables).



**Figure A1.** An example of a Bayesian network.

The link between variables is reflected in the form of the arrows connecting the corresponding nodes to each other, which expresses the relationships between the variables, what can be expressed as follows:

$$P(z_1, z_2, \dots, z_7) = P(z_7|z_5, z_4)P(z_5|z_3, z_1)P(z_4|z_3, z_2, z_1)P(z_3)P(z_2)P(z_1)$$

A more general notation of this type of relationship for  $n$  variables can be represented as

$$P(z_1, z_2, \dots, z_n) = P(z_n|z_{n-1}, \dots, z_1) \dots P(z_2|z_1)P(z_1)$$

The conditional probabilities in the above formula address the respective weights of the variables. A network of this type, as shown in the DAG above, is characterised by completeness and consistency, which finds its confirmation, i.e., from the chain representation of the joint distributions for the variables employed [8].

It is relatively straightforward to quantify the relationships between the nodes that make up the network, which is a direct result of the chain rule used in the model [8].

BN is based on probability theory and incorporates graph theory (as DAG), which greatly simplifies the complexity of reasoning about intricate phenomena. The method is used in a wide variety of fields, practically wherever there are spotted some kinds of dependencies between variables. In addition, BNs are the starting point for more advanced models, e.g., for conducting discrete time series analysis [90].

In this section, we also present the basic data on housing in the U.K., taken directly from the very large research surveys conducted as part of the cyclical EHS. We include these data in a synthetic form as follows (Tables A1–A19). The survey years are matching financial years, i.e., running April–March. For example, marking the results period as 2019–2020 actually means that the survey was conducted between April 2019 and March 2020.

**Table A1.** Trends in tenure, 1980 to 2019–2020 (percentages).

	Owner Occupiers				Social Renters			
	Own Outright	Buying with Mortgage	All Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters	All Tenures
2008–2009	31.4	36.5	67.9	14.2	8.8	9.1	17.8	100.0
2009–2010	31.7	35.7	67.4	15.6	8.1	9.0	17.0	100.0
2010–2011	32.0	34.0	66.0	16.5	8.4	9.1	17.5	100.0
2011–2012	31.7	33.5	65.3	17.4	8.1	9.2	17.3	100.0
2012–2013	32.5	32.7	65.2	18.0	7.7	9.1	16.8	100.0
2013–2014	32.7	30.7	63.3	19.4	7.3	10.1	17.3	100.0
2014–2015	33.2	30.4	63.6	19.0	7.3	10.1	17.4	100.0
2015–2016	33.9	29.0	62.9	19.9	7.0	10.2	17.2	100.0
2016–2017	34.1	28.4	62.6	20.3	6.8	10.3	17.1	100.0
2017–2018	33.9	29.6	63.5	19.5	6.8	10.2	17.0	100.0
2018–2019	34.4	29.4	63.8	19.3	6.8	10.1	16.8	100.0
2019–2020	34.9	29.7	64.6	18.7	6.6	10.1	16.7	100.0

**Table A2.** Tenure, by region, 2003–2004 to 2008–2009 to 2019–2020 (all households/percentage).

Region	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
North East												
owner occupiers	66.7	63.5	64.7	60.2	64.3	62.5	60.8	60.7	60.9	61.2	60.6	63.0
own outright	30.3	29.0	29.4	28.6	33.2	32.0	30.3	32.2	31.4	30.6	34.2	36.7
buying with mortgage	36.5	34.5	35.3	31.6	31.1	30.5	30.6	28.5	29.5	30.6	26.4	26.3
private renters	10.0	12.2	11.4	15.7	13.9	14.5	16.2	16.4	16.2	16.4	17.1	14.8
social renters	23.3	24.4	23.9	24.2	21.8	23.0	23.0	22.9	22.9	22.4	22.3	22.2
local authority	11.4	10.8	14.0	11.4	10.0	9.6	9.7	9.6	7.6	7.7	7.3	7.6
housing association	11.8	13.6	9.9	12.8	11.8	13.4	13.3	13.3	15.3	14.8	15.0	14.6
North West												
owner occupiers	69.9	67.1	65.8	68.9	66.2	63.8	64.7	63.4	63.6	63.7	64.4	65.4
own outright	31.9	30.7	31.4	32.8	32.0	32.8	34.6	34.5	34.2	33.5	33.4	34.4
buying with mortgage	38.0	36.4	34.4	36.1	34.2	31.0	30.1	28.9	29.4	30.2	31.0	31.0
private renters	11.7	13.4	16.3	14.1	17.4	18.0	17.1	18.6	18.6	18.4	18.1	17.3
social renters	18.4	19.5	17.9	17.0	16.4	18.3	18.1	18.0	17.8	17.9	17.5	17.3
local authority	4.9	5.3	5.9	4.5	3.6	2.9	3.0	2.8	2.8	3.0	2.8	2.6
housing association	13.5	14.2	12.0	12.5	12.8	15.3	15.1	15.3	15.0	14.8	14.7	14.7

Table A2. Cont.

Region	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
Yorks and Humber												
owner occupiers	67.6	67.4	67.6	64.8	64.6	61.9	62.6	61.8	61.0	64.4	64.5	63.1
own outright	30.7	33.3	31.4	28.9	32.3	31.5	32.5	35.5	33.2	33.5	35.9	35.1
buying with mortgage	36.9	34.1	36.2	35.9	32.3	30.4	30.1	26.3	27.8	30.9	28.6	28.0
private renters	14.9	14.1	14.0	16.6	17.4	19.8	19.2	20.2	21.1	18.1	18.3	19.8
social renters	17.6	18.4	18.3	18.6	17.9	18.3	18.2	18.1	17.9	17.5	17.2	17.1
local authority	10.7	11.0	10.4	10.9	9.4	10.0	10.1	9.8	9.7	9.8	9.5	9.3
housing association	6.8	7.4	7.9	7.7	8.5	8.2	8.1	8.2	8.1	7.7	7.7	7.9
East Midlands												
owner occupiers	73.3	71.8	69.1	70.6	69.9	65.4	66.6	66.7	66.8	66.9	67.3	67.4
own outright	35.9	32.3	32.8	35.9	37.8	34.8	37.4	34.3	35.7	36.4	38.1	33.9
buying with mortgage	37.4	39.5	36.3	34.7	32.2	30.6	29.2	32.4	31.1	30.5	29.1	33.5
private renters	10.1	14.5	14.0	13.8	16.3	19.0	17.5	17.6	17.8	18.0	17.8	17.8
social renters	16.7	13.7	16.8	15.6	13.8	15.6	15.9	15.7	15.4	15.1	14.9	14.8
local authority	10.7	8.3	10.3	9.3	8.8	9.2	9.4	9.2	8.8	8.7	8.6	8.4
housing association	6.0	5.4	6.6	6.2	5.0	6.4	6.5	6.5	6.6	6.3	6.3	6.4
West Midlands												
owner occupiers	68.2	68.1	67.9	65.5	68.1	66.3	65.8	63.9	63.9	65.6	65.6	65.6
own outright	32.3	34.0	34.8	35.6	34.3	34.9	36.5	34.3	37.2	36.9	40.5	38.7
buying with mortgage	35.9	34.1	33.1	29.9	33.7	31.4	29.3	29.6	26.8	28.7	25.1	26.9
private renters	11.4	14.4	14.6	15.6	14.5	15.0	15.6	17.5	17.8	16.0	16.5	16.5
social renters	20.3	17.4	17.5	19.0	17.4	18.7	18.6	18.5	18.3	18.4	17.9	17.9
local authority	10.7	8.9	8.4	7.9	8.1	8.8	8.7	8.5	8.2	7.9	7.9	7.8
housing association	9.6	8.5	9.1	11.1	9.3	9.9	9.9	10.0	10.1	10.4	10.0	10.1
East of England												
owner occupiers	72.6	70.5	69.1	68.4	68.9	67.1	67.1	66.4	66.3	67.5	68.0	68.7
own outright	32.9	35.0	34.9	33.7	34.7	35.9	36.8	35.5	36.1	36.9	36.3	37.1
buying with mortgage	39.7	35.5	34.2	34.7	34.2	31.2	30.3	30.9	30.2	30.6	31.7	31.6
private renters	12.4	12.8	14.7	16.7	16.5	17.0	17.3	18.0	18.2	17.1	16.9	16.2
social renters	15.0	16.8	16.1	14.9	14.6	15.9	15.7	15.6	15.5	15.4	15.1	15.1
local authority	6.1	7.4	6.1	6.0	7.1	6.3	6.2	6.2	6.2	6.0	5.9	5.9
housing association	8.9	9.3	10.0	8.8	7.5	9.6	9.4	9.4	9.4	9.4	9.2	9.2
London												
owner occupiers	52.9	53.5	50.7	49.2	50.7	48.2	49.5	49.3	47.5	48.4	49.9	49.6
own outright	21.7	22.1	21.5	19.6	21.8	21.5	22.8	23.4	25.1	21.7	22.8	23.4
buying with mortgage	31.2	31.4	29.2	29.7	28.9	26.6	26.7	25.9	22.4	26.6	27.1	26.2
private renters	21.5	23.0	25.4	26.1	24.1	29.6	27.2	28.1	30.0	29.0	27.4	28.1
social renters	25.5	23.5	23.9	24.7	25.2	22.3	23.3	22.5	22.4	22.6	22.7	22.2
local authority	16.4	15.1	14.3	16.3	14.7	11.7	12.3	11.6	11.2	11.5	11.9	11.7
housing association	9.1	8.4	9.7	8.4	10.5	10.6	11.0	10.9	11.3	11.2	10.8	10.6
South East												
owner occupiers	72.7	72.4	71.1	69.9	68.3	68.8	68.1	67.9	68.0	68.1	68.2	70.9
own outright	33.1	33.1	35.4	33.9	32.5	35.1	33.8	36.7	36.3	35.5	34.8	37.6
buying with mortgage	39.6	39.3	35.7	36.0	35.8	33.7	34.3	31.2	31.6	32.6	33.4	33.3
private renters	14.3	15.9	15.9	17.5	18.7	17.8	18.8	19.1	18.9	18.8	18.8	16.0
social renters	13.0	11.7	13.0	12.5	13.0	13.4	13.1	13.0	13.1	13.1	13.0	13.1



Table A2. Cont.

Region	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
local authority	4.9	4.1	5.1	4.7	4.9	4.8	4.6	4.5	4.5	4.4	4.3	4.3
housing association	8.0	7.6	7.9	7.8	8.2	8.6	8.6	8.5	8.6	8.7	8.7	8.8
South West												
owner occupiers	69.8	72.9	70.9	70.2	69.8	69.3	69.1	68.2	68.0	68.8	68.1	69.7
own outright	37.1	37.0	37.6	38.6	39.6	38.9	36.6	41.1	39.4	42.8	39.3	41.5
buying with mortgage	32.7	35.9	33.3	31.7	30.2	30.3	32.5	27.1	28.6	26.0	28.8	28.2
private renters	17.2	16.0	16.4	17.4	18.3	17.7	17.8	18.6	18.9	18.3	19.1	17.3
social renters	13.0	11.1	12.7	12.4	11.9	13.1	13.1	13.1	13.1	12.9	12.9	13.0
local authority	5.0	4.1	4.5	3.8	3.8	4.2	4.2	3.8	3.8	3.7	3.7	3.7
housing association	8.0	7.0	8.2	8.6	8.2	8.9	8.9	9.3	9.3	9.2	9.2	9.4
England (excl. London)												
owner occupiers	70.4	69.7	68.6	67.9	67.7	66.0	66.0	65.3	65.2	66.2	66.3	67.2
own outright	33.1	33.2	33.8	33.7	34.4	34.6	35.0	35.8	35.7	36.0	36.5	36.9
buying with mortgage	37.3	36.4	34.8	34.2	33.3	31.4	31.1	29.5	29.5	30.1	29.8	30.3
private renters	13.0	14.3	15.0	16.0	17.0	17.5	17.6	18.4	18.6	17.8	17.9	17.0
social renters	16.6	16.0	16.4	16.1	15.3	16.5	16.4	16.3	16.2	16.0	15.8	15.8
local authority	7.5	7.0	7.4	6.7	6.5	6.5	6.4	6.2	6.0	6.0	5.9	5.8
housing association	9.1	9.0	9.0	9.3	8.9	10.0	9.9	10.0	10.1	10.1	10.0	10.0
all England (excl. London)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
sample size	17,691	17,042	17,556	13,829	13,652	13,276	13,174	13,468	12,970	13,395	13,431	13,332

Table A3. Demographic and economic characteristics, 2019–2020 (percentages).

	Own Outright	Buying with Mortgage	All Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters	All Households
age of HRP								
16–24	0.3	1.1	0.7	10.8	2.8	3.8	3.4	3.0
25–34	1.0	18.4	9.0	31.7	14.1	15.0	14.7	14.2
35–44	3.2	27.5	14.4	24.1	17.2	17.0	17.1	16.6
45–54	10.0	32.0	20.1	15.9	21.3	21.9	21.6	19.6
55–64	23.0	15.6	19.6	9.1	17.8	16.3	16.9	17.2
65 or over	62.5	5.5	36.3	8.4	26.9	26.0	26.4	29.4
economic status of HRP								
full-time work	25.5	82.8	51.8	67.5	28.6	32.0	30.6	51.2
part-time work	10.3	8.8	9.6	9.8	13.9	14.4	14.2	10.4
retired	60.9	4.8	35.1	7.7	26.5	24.7	25.4	28.4
unemployed	0.5	0.8	0.6	2.9	6.9	5.7	6.2	2.0
full-time education	0.1	0.1	0.1	4.0	0.7	0.9	0.8	0.9
other inactive	2.7	2.7	2.7	8.1	23.4	22.3	22.7	7.1
household type								
couple no dependent child(ren)	45.1	26.5	36.5	22.2	11.6	13.4	12.7	29.9
couple with dependent child(ren)	4.2	35.6	18.6	22.5	13.0	12.6	12.7	18.4
couple with dependent and independent child(ren)	1.7	4.1	2.8	1.8	3.7	3.1	3.3	2.7

Table A3. Cont.

	Own Outright	Buying with Mortgage	All Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters	All Households
couple with independent child(ren)	7.1	8.4	7.7	2.7	4.6	4.7	4.7	6.3
lone parent with dependent child(ren)	0.9	3.2	2.0	10.0	12.5	14.2	13.5	5.4
lone parent with dependent and independent child(ren)	0.3	1.2	0.7	0.8	2.8	3.3	3.1	1.1
lone parent with independent child(ren)	3.9	2.5	3.3	2.5	6.9	4.8	5.6	3.5
two or more families	1.5	1.7	1.6	2.0	2.1	1.9	2.0	1.7
lone person sharing with other lone persons	1.6	1.3	1.5	10.0	2.3	1.4	1.7	3.1
one male	12.2	8.8	10.6	15.1	18.4	17.9	18.1	12.7
one female	21.5	6.6	14.7	10.5	22.0	22.8	22.5	15.2
long term illness or disability								
yes	38.9	21.3	30.8	25.0	53.3	54.1	53.8	33.6
no	61.1	78.7	69.2	75.0	46.7	45.9	46.2	66.4
weekly gross household income								
first quintile (lowest incomes)	20.2	4.5	13.0	20.0	48.6	46.4	47.3	20.0
second quintile	24.8	10.9	18.4	21.8	24.9	23.5	24.0	20.0
third quintile	21.5	18.7	20.2	22.6	14.2	17.7	16.3	20.0
fourth quintile	19.2	27.5	23.0	19.6	9.2	8.6	8.9	20.0
fifth quintile (highest incomes)	14.4	38.5	25.5	15.9	3.0	3.7	3.5	20.0
household has internet access at home								
yes	87.7	98.3	92.6	91.6	78.0	79.2	78.7	90.1
no	12.3	1.7	7.4	8.4	22.0	20.8	21.3	9.9
all households	34.9	29.7	64.6	18.7	6.6	10.1	16.7	100.0

Source: English Housing Survey, full household sample.

Table A4. Households with dependent children, by tenure, 2003–2004 to 2019–2020 (percentages).

	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
own outright												
with children	8.3	8.5	8.2	8.8	7.7	7.8	7.6	8.2	8.6	8.2	8.1	8.0
no children	91.7	91.5	91.8	91.2	92.3	92.2	92.4	91.8	91.4	91.8	91.9	92.0
buying with mortgage												
with children	43.9	44.4	44.8	43.9	45.8	45.5	45.9	47.1	44.4	45.7	45.7	45.0
no children	56.1	55.6	55.2	56.1	54.2	54.5	54.1	52.9	55.6	54.3	54.3	55.0
private renters												
with children	29.8	31.3	31.7	35.1	33.1	36.0	37.4	35.7	37.9	34.7	36.9	36.0
no children	70.2	68.7	68.3	64.9	66.9	64.0	62.6	64.3	62.1	65.3	63.1	64.0

**Table A4.** *Cont.*

	2008/ 2009	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
local authority												
with children	34.8	34.0	33.9	30.4	32.1	33.7	34.8	30.3	35.3	33.4	33.1	33.6
no children	65.2	66.0	66.1	69.6	67.9	66.3	65.2	69.7	64.7	66.6	66.9	66.4
housing association												
with children	33.9	32.0	34.7	30.4	31.8	32.1	33.8	32.6	34.1	33.3	35.4	34.7
no children	66.1	68.0	65.3	69.6	68.2	67.9	66.2	67.4	65.9	66.7	64.6	65.3
all social renters												
with children	34.3	33.0	34.4	30.4	31.9	32.8	34.2	31.7	34.6	33.3	34.5	34.3
no children	65.7	67.0	65.6	69.6	68.1	67.2	65.8	68.3	65.4	66.7	65.5	65.7
all households												
with children	29.0	29.0	29.1	28.9	28.8	29.1	29.5	29.0	29.2	28.7	29.2	28.6
no children	71.0	71.0	70.9	71.1	71.2	70.9	70.5	71.0	70.8	71.3	70.8	71.4

**Table A5.** Recent first-time buyers, London and outside London, 2003–2004 to 2019–2020 (percentages).

	London	England (Excluding London)	All First Time Buyers
2008–2009	18.1	81.9	100.0
2009–2010	18.5	81.5	100.0
2010–2011	17.4	82.6	100.0
2011–2012	17.9	82.1	100.0
2012–2013	21.4	78.6	100.0
2013–2014	25.3	74.7	100.0
2014–2015	22.3	77.7	100.0
2015–2016	17.4	82.6	100.0
2016–2017	16.0	84.0	100.0
2017–2018	15.2	84.8	100.0
2018–2019	17.4	82.6	100.0
2019–2020	13.2	86.8	100.0

**Table A6.** Demographic and economic characteristics, recent first-time buyers, 2019–2020.

	Thousands of Households	Percentages
age of HRP		
16–24	70	8.5
25–34	538	65.1
35–44	180	21.7
45 or over	39	4.7
weekly gross household income		
first quintile (lowest incomes)	28	3.4
second quintile	100	12.1
third quintile	186	22.4
fourth quintile	282	34.1
fifth quintile (highest incomes)	231	28.0
ethnicity of HRP		
white	704	85.1
ethnic minority background	123	14.9
household type		
couple, no dependent child(ren)	374	45.3
couple with dependent child(ren)	253	30.6

**Table A6.** *Cont.*

	Thousands of Households	Percentages
lone parent with dependent child(ren)	12	1.5
other multi-person households	31	3.7
one person households	156	18.9
all recent first-time buyers	827	100.0
sample size	394	

**Table A7.** Mean and median mortgage payments, London and England, 2008–2009 to 2019–2020.

All Owner Occupiers Buying with a Mortgage			
	GBP Per Week (Mean)	GBP Per Week (Median)	
London			
2008–2009	206	178	
2009–2010	196	165	
2010–2011	203	163	
2011–2012	200	162	
2012–2013	199	164	
2013–2014	218	185	
2014–2015	227	185	
2015–2016	235	196	
2016–2017	233	204	
2017–2018	244	219	
2018–2019	246	222	
2019–2020	263	231	
England (excluding London)			
2008–2009	138	120	
2009–2010	134	115	
2010–2011	137	115	
2011–2012	134	114	
2012–2013	144	118	
2013–2014	145	118	
2014–2015	151	128	
2015–2016	150	127	
2016–2017	151	127	
2017–2018	154	132	
2018–2019	162	138	
2019–2020	170	138	

**Table A8.** Mean and median weekly rents, London and England, in GBP, 2008–2009 to 2019–2020.

	Private Renters	Local Authority	Housing Association	All Social Enters	Private Renters	Local Authority	Housing Association	All Social Renters
	GBP per week (mean)				GBP per week (median)			
London								
2008–2009	233	80	98	86	208	81	97	86
2009–2010	254	90	102	95	231	89	98	92
2010–2011	241	94	115	102	228	90	100	95
2011–2012	258	100	118	106	229	97	106	100
2012–2013	258	106	126	114	242	100	115	106
2013–2014	281	119	131	125	254	110	125	115
2014–2015	298	122	137	129	277	112	127	120
2015–2016	300	120	139	129	284	115	132	124
2016–2017	309	129	135	132	288	119	129	123

Table A8. Cont.

	Private Renters	Local Authority	Housing Association	All Social Enters	Private Renters	Local Authority	Housing Association	All Social Renters
2017–2018	312	127	139	133	300	120	128	124
2018–2019	341	124	139	131	319	120	129	122
2019–2020	342	128	148	138	317	122	134	127
England (excluding London)								
2008–2009	130	61	71	67	120	60	69	65
2009–2010	130	64	75	70	120	63	73	68
2010–2011	137	67	78	73	125	65	75	70
2011–2012	139	70	83	78	127	68	80	74
2012–2013	140	74	88	82	129	72	84	79
2013–2014	145	79	92	87	131	78	88	84
2014–2015	147	84	96	91	133	81	92	88
2015–2016	153	87	99	95	137	83	95	90
2016–2017	158	87	100	95	138	84	96	92
2017–2018	158	87	100	96	140	84	94	91
2018–2019	162	86	100	95	139	83	95	90
2019–2020	159	89	98	95	144	85	94	91

Table A9. Mortgage/rent as a proportion of household income (including and excluding housing benefit), by tenure, 2010–2011 to 2019–2020 (percentages).

	Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters	Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters
household income (incl. housing benefit)					joint income of HRP and partner only (including housing benefit)					
2010–2011	17.9	35.4	26.0	27.2	26.7	2010–2011	19.0	44.4	27.9	29.1
2011–2012	17.9	35.5	26.4	28.9	27.7	2011–2012	19.2	42.1	28.3	30.7
2012–2013	18.8	34.2	26.5	29.4	28.0	2012–2013	20.2	39.8	28.6	31.6
2013–2014	17.9	33.9	27.0	29.7	28.6	2013–2014	19.3	43.0	29.0	32.1
2014–2015	17.3	36.4	28.2	29.9	29.2	2014–2015	18.6	45.5	30.6	32.6
2015–2016	17.7	35.0	27.6	28.6	28.2	2015–2016	18.8	41.4	29.9	31.0
2016–2017	18.2	34.3	27.1	28.7	28.1	2016–2017	19.4	41.1	29.6	31.4
2017–2018	17.2	32.9	26.8	28.7	28.0	2017–2018	18.4	41.1	29.5	30.9
2018–2019	17.7	32.8	26.2	27.4	26.9	2018–2019	19.1	40.3	28.9	30.2
2019–2020	17.8	31.9	26.7	26.5	26.6	2019–2020	19.3	38.4	29.1	28.9
household income (excl. housing benefit)					joint income of HRP and partner only (excluding housing benefit)					
2010–2011	17.9	43.7	35.4	37.0	36.2	2010–2011	19.0	53.4	37.9	39.7
2011–2012	17.9	44.4	35.6	39.6	37.7	2011–2012	19.2	52.0	38.3	42.3
2012–2013	18.8	40.7	35.6	41.6	38.9	2012–2013	20.2	47.1	38.8	44.8
2013–2014	17.9	41.0	36.0	40.3	38.5	2013–2014	19.3	51.5	38.9	43.8
2014–2015	17.3	43.4	36.5	40.7	38.9	2014–2015	18.6	53.3	39.6	44.5
2015–2016	17.7	41.0	36.1	37.8	37.1	2015–2016	18.8	48.1	39.6	41.0
2016–2017	18.2	39.0	35.7	38.1	37.1	2016–2017	19.4	46.2	39.4	41.7
2017–2018	17.2	36.8	35.1	38.1	36.9	2017–2018	18.4	45.3	38.5	41.0
2018–2019	17.7	37.3	33.8	35.5	34.8	2018–2019	19.1	45.3	37.3	39.2
2019–2020	17.8	36.5	34.5	34.2	34.3	2019–2020	19.3	43.5	37.9	37.3

Table A10. Number and proportion of households in rent arrears, by tenure, 2011–2012 to 2016–2017 and 2019–2020 (percentages).

	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2019–2020
private renters							
currently in arrears	5.0	3.7	4.2	4.4	4.1	3.8	2.6
have been in arrears	5.9	5.0	5.0	4.7	5.2	5.3	4.9



**Table A10.** *Cont.*

	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2019–2020
all arrears in last year	10.9	8.7	9.2	9.1	9.3	9.1	7.6
local authority							
currently in arrears	12.9	13.4	16.4	13.8	11.6	10.8	11.3
have been in arrears	10.9	14.7	14.6	13.6	14.8	13.4	13.6
all arrears in last year	23.8	28.1	31.0	27.4	26.4	24.1	24.9
housing association							
currently in arrears	13.2	11.0	14.4	14.4	12.4	13.0	11.6
have been in arrears	9.9	11.5	14.1	13.5	12.3	12.4	10.1
all arrears in last year	23.1	22.6	28.5	27.9	24.7	25.4	21.6
all social renters							
currently in arrears	13.1	12.2	15.3	14.2	12.1	12.1	11.5
have been in arrears	10.4	13.1	14.3	13.5	13.3	12.8	11.5
all arrears in last year	23.4	25.3	29.6	27.7	25.4	24.9	23.0

**Table A11.** Ease of affording rent, social and private renters, 2019–2020 (percentages).

	Private Renters	Local Authority	Housing Association	All Social Renters	All Renters
very easy	23.7	22.7	25.3	24.2	24.0
fairly easy	49.3	49.7	47.5	48.4	48.9
very or fairly easy	73.0	72.4	72.8	72.6	72.9
fairly difficult	20.3	18.9	18.8	18.8	19.7
very difficult	6.6	8.7	8.4	8.5	7.4
very or fairly difficult	27.0	27.6	27.2	27.4	27.1
total	100.0	100.0	100.0	100.0	100.0
sample size	2267	1094	1448	2542	4809

**Table A12.** Receipt of housing benefit and mean amount received, 2008–2009 to 2019–2020 (percentages).

	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020
private renters	19.5	23.7	24.6	25.5	25.0	25.6	26.6	23.7	22.4	19.6	20.3	20.3
social renters	59.1	61.9	62.6	64.0	65.6	63.2	62.5	58.8	59.0	59.7	57.4	56.4
	GBP per week (means)											
private renters	100	112	107	115	109	108	108	111	103	100	119	113
social renters	62	67	71	73	77	78	80	81	82	81	80	81

**Table A13.** Receipt of housing benefit, by economic status, 2008–2009 to 2019–2020 (percentages).

	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
private renters												
working full-time or part-time	7.3	9.3	11.1	12.3	12.4	13.6	17.5	12.8	13.7	12.0	11.7	11.2
not working	47.5	55.8	55.2	54.8	57.1	56.9	48.6	54.4	46.3	44.2	44.2	51.2

Table A13. Cont.

	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
local authority												
working full-time or part-time	18.3	20.7	23.9	27.5	34.3	31.4	26.9	27.2	29.4	30.2	31.2	25.5
not working	80.2	83.8	83.8	84.2	83.5	82.3	81.8	82.4	82.1	80.9	78.8	80.0
housing association												
working full-time or part-time	19.4	19.8	23.5	28.7	30.3	32.3	31.2	29.9	30.0	28.6	26.2	27.3
not working	79.9	81.3	78.8	80.3	83.2	80.6	83.0	79.8	80.1	81.3	78.7	80.8
all social renters												
working full-time or part-time	18.9	20.2	23.7	28.2	32.2	31.9	29.4	28.9	29.8	29.2	28.1	26.7
not working	80.1	82.5	81.2	82.1	83.3	81.3	82.5	80.9	80.9	81.2	78.8	80.5
all renters												
working full-time or part-time: on housing benefit	11.7	13.1	15.2	17.5	18.5	19.4	21.4	18.1	19.0	17.6	17.2	16.5
not on housing benefit	88.3	86.9	84.8	82.5	81.5	80.6	78.6	81.9	81.0	82.4	82.8	83.5
not working on housing benefit	71.3	74.5	73.4	73.4	75.0	73.3	71.0	71.8	68.6	69.5	66.9	71.3
not on housing benefit	28.7	25.5	26.6	26.6	25.0	26.7	29.0	28.2	31.4	30.5	33.1	28.7

Table A14. Buying expectations, social and private renters, 2019–2020 (percentages).

	Private Renters	Local Authority	Housing Association	All Social Renters	All Renters
expect to buy					
yes	59.5	26.8	29.5	28.4	44.7
no	40.5	73.2	70.5	71.6	55.3
all	100.0	100.0	100.0	100.0	100.0
expect to buy current home					
yes	13.3	58.6	41.8	48.2	23.8
no	86.7	41.4	58.2	51.8	76.2
all	100.0	100.0	100.0	100.0	100.0
how long before expect to buy					
less than 2 years	26.7	18.5	17.4	17.8	24.1
2 years but less than 5 years	34.8	36.6	32.7	34.1	34.6
5 years but less than 10 years	26.9	25.4	29.8	28.2	27.3
10 years or more	11.5	19.6	20.1	19.9	14.0
all	100.0	100.0	100.0	100.0	100.0

**Table A15.** Number and proportion of renters who expect to buy, 2008–2009 to 2019–2020 (percentages).

	Private Renters	Local Authority	Housing Association	All Social Renters	All Renters
2008–2009	59.2	29.8	24.5	27.1	40.4
2009–2010	60.4	25.1	23.8	24.4	40.6
2010–2011	59.3	22.2	23.4	22.8	39.7
2011–2012	59.0	21.4	19.3	20.3	39.4
2012–2013	60.7	26.2	19.7	22.6	42.0
2013–2014	61.1	26.8	24.1	25.2	43.8
2014–2015	57.1	24.8	23.2	23.8	41.0
2015–2016	59.5	27.4	26.4	26.8	44.1
2016–2017	60.5	30.6	29.6	30.0	46.3
2017–2018	58.0	26.2	24.9	25.4	42.5
2018–2019	55.8	25.9	28.1	27.2	42.3
2019–2020	59.5	26.8	29.5	28.4	44.7

**Table A16.** Average number of years in current home and in the private rented sector, by tenure, 2010–2011 to 2019–2020—average number of years in current home (mean).

	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020
own outright	23.8	24.3	24.0	23.5	24.1	24.4	23.8	24.3	24.7	23.8
buying with mortgage	10.0	10.3	10.7	10.3	10.4	10.2	10.0	10.3	10.3	10.0
all owner occupiers	16.7	17.1	17.3	17.1	17.5	17.8	17.5	17.8	18.1	17.4
private renters	3.7	3.8	3.8	3.5	4.0	4.3	3.9	4.1	4.4	4.3
local authority	12.3	13.4	12.8	12.7	12.2	12.9	12.0	13.4	12.6	13.3
housing association	10.6	10.2	10.0	10.7	10.9	10.7	10.8	10.9	10.8	11.4
all social renters	11.5	11.7	11.3	11.5	11.4	11.6	11.3	11.9	11.6	12.2
all tenures	13.6	13.9	13.9	13.5	13.9	14.1	13.7	14.1	14.3	14.1

**Table A17.** Previous tenure by current tenure, 2019–2020 (u indicates that the sample size is too small to make a reliable estimate).

Current Tenure	New Household	Previous Tenure					All Social Renters	All Private Renters	All Households	Sample Size		
		Owner Occupiers			All Owner Occupiers	All Social Renters					All Private Renters	All Households
		Owned Outright	Buying with a Mortgage	All Owner Occupiers								
owned outright	u	111	32	143	0	13	162	93				
buying with a mortgage	71	18	146	164	u	179	415	194				
owner occupiers	78	129	177	307	u	192	578	287				
social renters	50	7	u	8	145	74	277	235				
private renters	131	25	73	99	23	703	956	544				
all tenures	258	160	251	415	169	969	1811	1066				
owned outright	u	68.2	19.5	87.7	0.0	7.9	100.0					
buying with a mortgage	17.1	4.3	35.1	39.6	u	43.1	100.0					
owner occupiers	13.5	22.3	30.7	53.1	u	33.2	100.0					
social renters	17.9	2.4	u	3.0	52.4	26.7	100.0					
private renters	13.7	2.6	7.6	10.4	2.4	73.5	100.0					
all tenures	14.3	8.8	13.9	22.9	9.3	53.5	100.0					
sample size	145	96	130	229	144	548	1066					

Table A18. Well-being, by tenure, 2019–2020.

	Own Outright	Buying with Mortgage	All Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters	All Households
Life satisfaction	8.0	7.8	7.9	7.4	7.0	7.1	7.1	7.7
Life is worthwhile	8.1	8.1	8.1	7.8	7.4	7.5	7.4	7.9
Happiness	7.8	7.7	7.8	7.3	6.9	7.1	7.0	7.6
Anxiety	2.4	2.7	2.5	2.9	3.3	3.2	3.2	2.7

Table A19. Loneliness, by tenure, 2019–2020 (percentages).

	Own Outright	Buying with Mortgage	All Owner Occupiers	Private Renters	Local Authority	Housing Association	All Social Renters	All House- holds
How often do you feel lonely?								
Often or always	5.0	3.1	4.2	4.5	12.9	11.8	12.2	5.8
Some of the time	10.4	9.9	10.2	14.1	19.3	20.1	19.8	12.8
Occasionally	16.1	17.1	16.5	21.5	14.5	18.9	17.2	17.6
Hardly ever	27.3	33.9	30.1	28.9	20.7	20.1	20.3	28.0
Never	41.2	36.0	39.1	31.1	32.5	29.2	30.4	35.9
sample size	1672	1126	2798	984	614	923	1537	5319

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