DREAM

Modeling Household Formation and Housing Demand in Denmark

- The Dynamic Microsimulation Model SMILE

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DREAM

Preface

The DREAM group has developed the individual based microsimulation model SMILE (Simulation Model for Individual Lifecycle Evaluation), which project the housing demand on the Danish housing market. The purpose is to provide a basis for evaluation the future housing demand. The microsimulation model consists of a demographic module and a housing module. The demographic module predicts the household structure of the Danish population, which cause a population projection divided on location/province, gender, age, origin, education, labour market status, family structure (i.e. couples or singles) and the number of children in the family. Such projection has not previously existed in Denmark. The housing module predicts the housing demands on basis of the household structure and is described by the housing locations (province and town size), owner and rental status (housing type), use (physical use), area (housing size) and construction year (housing age).

This report documents the model and consequently the methods and data basis of the prediction. It also presents results for the predictions baseline scenario, which uses the initial population and housing stock of 2010 as well as incidents and behaviour within a historical period. The baseline scenario ends in year 2040.

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Summary

The current business cycle has brought housing markets firmly into the macroeconomic mainstream. In this project we build a detailed model of housing demand and use it to forecast key aggregate and compositional features of Danish housing demand until 2040.

Individual housing demand is determined by a number of economic factors. Empirical studies show disposable income to have a very large effect on a household's choice of housing. Additional variables affecting the choice of housing include the interest rate, the price of existing housing, household wealth and the level of inflation.

Aggregate housing demand is to a larger extent determined by demographics. The size and age distribution of the population, the pattern of family types and the educational background of the population are examples of factors with a large influence on the long-run demand for housing. As an example, an increase in the number of elderly people will result in an increase in demand for types of housing suitable for the elderly. Likewise, an increase in the number of students will cause an increase in demand for housing suitable for students, this demand typically being for smaller apartments in larger urban areas.

In the very short run, the supply of housing is fixed at the level of the existing housing stock. Consequently, a change in demand will reveal itself through price changes in the market for privately owned housing and through the length of waiting lists or the level of rents in the market for rented housing. In the longer run, the supply of housing will adjust to demand through construction of new housing or demolition of existing housing.

The long-term evolution of housing demand will ultimately affect the size of the housing stock and hence yield an indication of the future need for construction of new housing. Forecasting the evolution of demand for different types of housing is very useful as the supply side in this market is slow moving since planning and building are lengthy processes.

To forecast the demand for housing we develop a model based on detailed demographic information. The model describes both the evolution of cohabitation patterns and family formation and dissolution, as well as the movements of households between various types of housing over time. Based on this, we are able to forecast the number of dwellings required so that each household has one unit of housing. This number is referred to as *the potential housing demand*.

The next section gives a short introduction to the method used to forecast household patterns and housing demand. The method is based on microsimulation by which an initial population is projected one year at a time through the realization of one or more possible events. These events include, among other things, births, deaths, the formation and break-up of couples, and the movements of households across different types of dwellings.

The last section summarizes the main results of our work. The initial population of approximately 5.5 million individuals is projected to increase to approximately 6.0 million individuals in 2040. In addition we forecast that an increasingly larger share of the population will be living in single-adult households. As a result, the demand for dwellings is forecasted to increase from 2.59 million in 2010 to 2.94 million in 2040. This corresponds to a net increase of 11,775 dwellings a year if the increasing demand is to be met.

The projection method

Dwellings are occupied by households. Consequently, the forecast of housing demand is based on a forecast of the household structure with each household being associated with a unique dwelling. The household structure is forecasted using a microsimulation model. A defining feature of such models is that they are based on individual "entities" which can be either individual persons or families.

The microsimulation in the present work is based on an initial population where each individual is described by a number of characteristics including gender, age, education, family type, etc. It is also registered which family an individual belongs to, and which type of dwelling the family occupies. The simulation forecasts the initial population from period to period where each period corresponds to one year. In the process the characteristics of each individual are updated each period. The updating is achieved by "exposing" individuals and households to a number of possible events. For an individual, possible events include to begin or finish an education, and of course to die. For a family, examples of events include marriage, divorce, and to move to another dwelling. In order to determine whether or not a specific event is realized, each person is "asked" a question to which the answer is either "yes" or "no". The questions depend on the characteristics of the person. A typical question would be to ask a 30 year old male in a single-adult household whether he will find a partner during the following year.

Answers to these questions are randomly determined using transitional probabilities which depend on the characteristics of the individual. This is the probability that a specific event takes place during the following year. In the example given above, this is the probability that a single 30 year old male finds a partner during the following year. Transitional probabilities are calculated based on historical observations. If the event is found to take place, the effects of it will be implemented in the model. To continue the example, this requires that a single female also has answered "yes" to the question of whether she will find a partner, and in this case the two individuals will form a couple. In the following period, the male (and the female) will not be asked whether he (or she) will find a partner. However, if the event does not take place, the individuals will be asked the same question in the following period. In this way, it is possible to simulate the remaining life cycle for all individuals in the initial population and thereby form long-run projections.

Box 1 gives an example of a simple microsimulation model used to project the total population based on individual births and deaths.

Box 1. An illustrative microsimulation model.

To illustrate the principles and dynamics of microsimulation, a simple model is presented below where only births and deaths affect the population.

The model begins in period *t* where the initial population is known and consists of a number of individuals that are divided into families. Figure B.1 below illustrates a population consisting of 8 individuals divided into 5 families. Specifically, the population consists of a single female without children, a couple (two adults) with one child, an elderly male, a couple without children and a single male without children. The age of each individual is registered, and by noting whether a family contains one or two adults it is possible to determine whether an individual is single or part of a couple.

Next, we want to simulate the evolution of the population from period *t* to period *t + 1*. This is done by asking each individual or each family a number of questions to which the answers are either "yes" or "no". It is then determined whether or not an event occurs by using

Box 1 (cont.). An illustrative microsimulation model.

transitional probabilities based on historical data.

In this example, we use two transitional probabilities denoting the likelihood that a female gives birth and the likelihood that an individual dies respectively. The probability of giving birth depends on the age of the female and on whether or not she is part of a couple. The probability of death depends only on the individual's age. The respective probabilities are shown in the figure below and are calculated based on data for the period 2008–2010. As an example, it is seen from the data that there are 43,961 individuals aged 88 during the three historical years. Of these, 5,485 die before reaching their 89th year. Consequently, the probability of death for an 88 year old individual is calculated to be 5,485 / 43,961 = 0.1258.

Figure B.1. Illustration of the simple microsimulation model.

Time						
Period *t*		**Single female** 42 years old	**Couple with 1 child** Child1: 3 y.o. Female: 30 y.o. Male: 32 y.o.	**Single male** 88 y.o.	**Couple** Female: 27 y.o. Male: 30 y.o.	**Single male** 55 y.o.
Events in period *t*	**Birth**					
	Probability:	0.004	0.108	0	0.094	0
	Random number:	0.265	0.017	-	0.039	-
	Event occurs:	no	yes	no	yes	no
	Death					
	Probability:	0.0014	Child1: 0.0013 Female: 0.0004 Male: 0.0005	0.1258	Female: 0.0004 Male: 0.0004	0.0058
	Random number:	0.7285	Child1: 0.9719 Female: 0.7743 Male: 0.5625	0.1071	Female: 0.4769 Male: 0.5199	0.2075
	Event occurs:	no	no / no / no	yes	no / no	no
Period *t+1*		**Single female** 43 years old	**Couple, 2 children** Child2: 0 y.o. Child1: 4 y.o. Female: 31 y.o. Male: 33 y.o.		**Couple with 1 child** Child1: 0 y.o. Female: 28 y.o. Male: 31 y.o.	**Single male** 56 y.o.

The event "birth" is modeled at the family level, meaning that the family is asked if the female gives birth to a child which, if affirmative, is then added to the family during period *t*. First, the family including the single female is asked whether she gives birth to a child during period *t*. The probability associated with this is shown in the figure and equals 0.004. In other words, is not very likely that the female will give birth to a child. This is due to the fact that she is single and at the end of her fertile period of life (fertility is assumed to depend on these two factors). In order to determine whether a child is born, a random number between 0 and 1 is drawn. The realization of this turns out to be 0.265 as shown in the figure. Since the randomly drawn number is larger than the probability of birth, the single female does not give birth during period *t*.

In a similar way, it is simulated whether the remaining four families have a child during

Box 1 (cont.). Simple illustrative microsimulation model.

period *t*. The probabilities that the two families involving couples (two adults) have a child are relatively high due to the fact that they involve couples and that the females are of an age where fertility is high. A male cannot give birth and therefore the probability of birth is zero for both single males. After simulating births, it is seen that the two families involving couples have a child during period *t*. This is due to the fact that the two randomly drawn numbers are lower than the respective probabilities of birth. As a consequence, a child is added to each of these families at the end of period *t* (or at the beginning of period *t + 1*). In total, two births have taken place during period *t* while the remaining three families have not increased in size.

The event "death" is modeled at the personal level, meaning that each individual person is asked whether he or she dies during period *t*. This is done with the same method used to simulate births. The figure below shows the probabilities of death for all individuals. The probability is relatively low for individuals below the age of 50 while it is 0.6 percent for the single male aged 55 and 12.6 percent for the single male aged 88. For each individual, a random number is then drawn which determines whether the person in question dies in period *t*. Only in the case of the single male aged 88 is the randomly drawn number lower than the probability of death, and hence this person is the only one to die during the period. All other individuals continue to be alive in period *t + 1*.

By asking every family whether the female gives birth to a child and each person whether he or she dies during the period, the evolution of the total population from period *t* to *t + 1* has been simulated. The number of deaths and births can be found by counting the total number of occurrences of events during period *t*. In the example, this amounts to 2 births and 1 death.

By adding newborns to the relevant families and by removing individuals who have died, the total population has been simulated one period ahead. Similarly, the age of all individuals is increased by 1 as the length of the period is assumed to be one year. It is now possible to establish the population in period *t + 1* and it consists of 9 individuals divided into 4 families.

By applying the same method to the population in period *t + 1*, the total population can be projected into period *t + 2*, and through repeated application the population may be forecasted for as long as required.

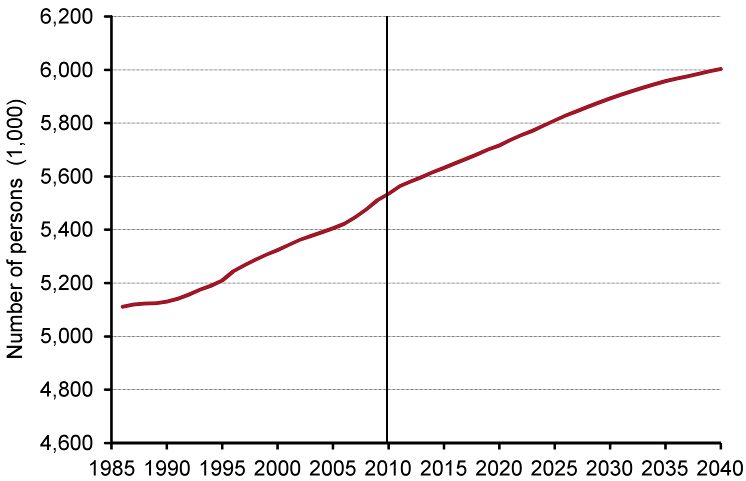
The model in Box 1 is a simplified microsimulation model containing only the events of birth and death. In our forecast of housing demand a considerably larger number of events are modeled. As in the simplified model, a distinction is made between events at the individual level and the family level. More specifically, a distinction is made between three types of events. Demographic events include birth, death, immigration, emigration and change of citizenship. Socioeconomic events include changes in labour market status and educational status, specifically to begin an education, to drop out of an education, to continue and to finish an education. Finally, household-specific events include the formation of a couple, the break-up of a couple, the event of a child leaving the parental home, and a family moving to a new dwelling. Each of these events is modelled based on transitional probabilities calculated from historical data. The demographic events determine the evolution of the total population while the household-specific events determine the evolution of the number of households. Probabilities associated with moving and with the choice of dwelling determine the pattern of household movements between dwellings and therefore the evolution of the aggregate demand for different types of housing.

Based on the events mentioned above, a projection can be made regarding the total size of the population as well as the age composition and pattern of cohabitation. The result is a projection of the number of households in Denmark, i.e. a projection of the number of single-individual households, the number of households involving couples, and for each household the number of children living at home. In the model, each household is associated with one dwelling that depends on the size of the household, the age composition of its members, their educational background, etc. Households move between existing dwellings based on historically observed moving patterns, and by projecting the number of households associated with each type of dwelling an estimate of the future housing demand is obtained.

The main results of the projection

The Danish population has increased from 2.4 million individuals around 1900 to 5.53 million in 2010. There has been positive population growth in all years except for a short period in the beginning of the 1980s. The observed tendency of an increasing population is expected to continue in the years to come, cf. Figure 1 which shows our model's forecast of the Danish population. Total population is predicted to reach around 6 million individuals in 2040. Until 2030 the population is expected to exhibit a constant growth of approximately 17,000 individuals per year. After 2030 population growth is expected to gradually decrease, so that in 2040 the total population will increase by around 8,000 individuals relative to the previous year. Total population increases due to positive net immigration (meaning that total immigration is expected to be higher than total emigration) as well as a positive surplus of births over deaths.

Figure 1. Total Danish population, 1986–2040.



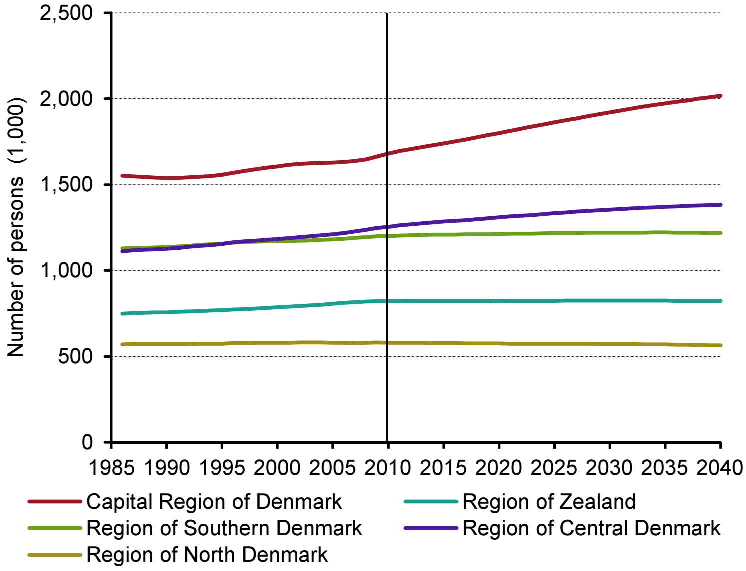
Sources: *Statistics Denmark and own calculations.*

Note: *The vertical line indicates the shift between historical data and forecast.*

In the forecast period the age composition of the population changes so that a larger share of the population consists of elderly people. This is caused by a continuation of the increasing life expectancy that has been observed historically, implying that future generations of elderly are expected to live considerably longer than current ones. As the large cohorts born after WW2 reach retirement age in the years to come, the increase in population until 2040 is expected to be caused almost exclusively by an increasing number of individuals above the age of 65. The number of individuals in this age group is expected to increase by more than 550,000 during the period 2010–2040 while the number of individuals aged 21–64 is expected to decrease by 120,000. Individuals aged 65 and above are consequently expected to make up an increasing share of the total population in coming years, increasing from 16.3 percent in 2010 to 24.3 percent in 2040.

There is also geographical variation in the evolution of population. The last few years have shown a tendency for a larger part of the population to locate near large urban areas, in particular the area surrounding Copenhagen and in Eastern Jutland (which includes Aarhus). The tendency is expected to continue in coming years, cf. Figure 2 which shows population forecasts for each of the five Danish regions[1]. Specifically, the population in the capital region of Denmark is expected to grow by 335,000 individuals until 2040, corresponding to an increase of slightly more than 11,000 individuals a year during the next 30 years. This population growth is higher than during the historical period in which the population in the capital region on average grew by 8,200 individuals per year from 1995 to 2010. In the region of Central Denmark, population is expected to grow by close to 130,000 individuals from 2010 to 2040. Until 2020 population growth in the region of Central Denmark is roughly at the level of the historical period of around 5,500 individuals per year. After that, population growth decreases in this region. In the regions of Zealand, Southern Denmark and Northern Denmark, only a modest change in population is expected.

Figure 2. Total Danish population by regions, 1986–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *The vertical line indicates the shift between historical data and forecast.*

The growing population until 2040 will increase the total number of families in Denmark, cf. Figure 3 which shows the number of households with one adult (singles) and two adults (couples) respectively. The number of families is, however, also affected by the pattern of cohabitation.

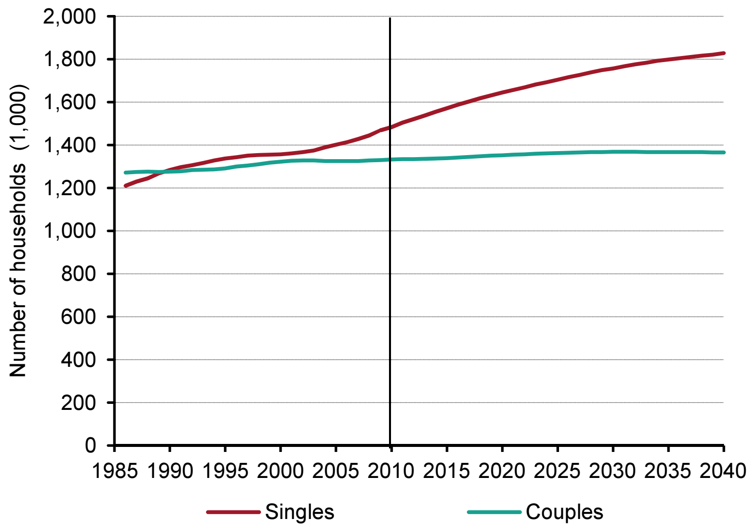
Historically, the evolution in the number of singles and couples has been dominated mainly by two counteracting effects: Firstly, an increasing share of individuals below the age of 65 live as singles. A number of explanations may be given for this. Young individuals tend to spend longer time on education today than previously so that they are older when they move in with a partner

[1] Denmark is divided into five regions and 98 municipalities. The five regions are the Capital Region of Denmark ("Region Hovedstaden"), the region of Zealand ("Region Sjælland"), the region of Southern Denmark ("Region Sydjylland"), the region of Central Denmark ("Region Midtjylland") and the region of Northern Denmark ("Region Nordjylland"). The regions have between 0.6 and 1.6 million inhabitants. In terms of acreage, the smallest region is the Capital Region of Denmark covering 2,561 square kilometers while the largest region, the region of Central Denmark, covers 13,142 square kilometers.

and form a family. But even after having finished their education, an increasing share of individuals live as singles. This is often explained by increasing wealth which makes life as a single financially feasible. Secondly, an increasing share of individuals above the age of 65 live as couples. This effect appears because individuals on average live longer. As longevity increases, fewer individuals live as singles because the time of death of the partner is postponed until higher ages. Historically, women have a higher average longevity than men, but the historical period shows a tendency for the longevity of males and females to converge. This also implies that individuals on average live fewer years after the death of their partner than previously.

The change in the aggregate composition of family structure is a reflection of the fact that the period 1986–2010 exhibits a higher growth in the number of singles than in the number of couples. The last part of the 1990s and the beginning of the new millennium show a temporary tendency for the number of couples to increase while the number of singles stagnates. This is caused by the mortality of the elderly starting to decrease from the mid-1990s. As a consequence, some of those who would otherwise have become single following the death of their partner will instead continue to live as part of a couple. This effect temporarily dominates the effect of changing family structure in which an increasing share of the population live as singles.

Figure 3. Number of households in Denmark divided by couples and singles, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

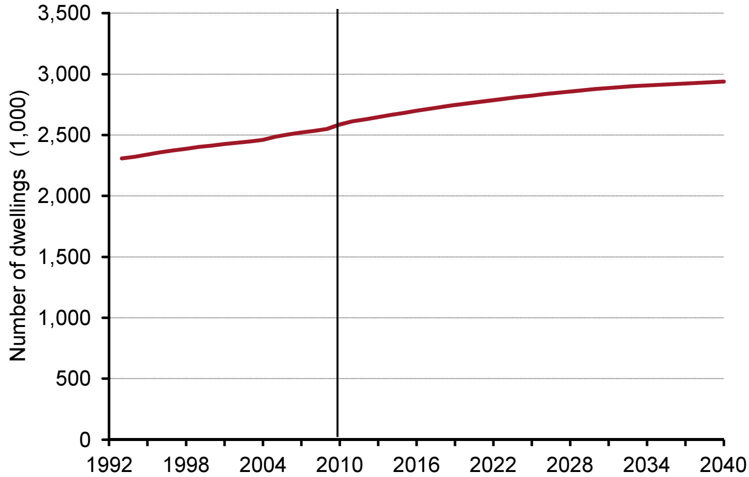
The tendency for a changing family structure is continued in the forecast and leads, along with an increasing population, to a larger total number of families. As in the historical period, the number of single-adult families grows at a relatively higher rate than the number of families involving couples. The number of single adults is thus expected to increase by nearly 350,000 individuals during the period 2010–2040. In the same period, the number of adults who live as couples increases by a little less than 70,000. This implies that a larger part of the population will consist of single adults as the share of singles, excluding children living at home, will grow from 35.8 percent of the population in 2010 to 40.1 percent in 2040.

The increase in the number of households causes an increase in the demand for dwellings. Figure 4 shows housing demand for the period 1993–2040. Housing demand is defined here as the number of dwellings needed if there is to be one dwelling for each household. In total, the increasing population and the change in the pattern of cohabitation increase the demand for dwellings from 2.59 million in 2010 to 2.94 million in 2040.

During the period 1993–2010, housing demand has seen an annual increase in the range of 10,000 to 27,000 with an average of 15,250 dwellings per year. In the beginning of our forecast, the annual increase in housing demand is maintained at the historical level; however, the growth rate of demand diminishes over time. Around 2040 housing demand is thus expected to increase with approximately 5,000 dwellings a year. In total, housing demand is expected to increase by 350,000 dwellings during the period 2010–2040. This corresponds to an annual net increase of 11,775 dwellings per year if demand is to be met. With depreciation of existing dwellings at a level of 5,000 per year, this requires the construction of new dwellings to be around 16,775 per year during the next three decades.

Approximately two thirds of the increase in total housing demand is explained by the overall increase in population. The remaining third is caused by the changing pattern of cohabitation whereby an increasing share of the population lives in households with only one adult.

Figure 4. Total Danish housing demand, 1993–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *The vertical line indicates the shift between historical data and forecast.*

Figure 5 shows housing demand until 2040 by types of dwelling. The model distinguishes between owner-occupied housing[2] and rented housing which in turn is further subdivided into social housing[3], cooperative housing[4], publicly owned rented housing[5] and privately owned rented housing[6]. Owner-occupied housing is the most common type of housing accounting for a little more than half of all dwellings.

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[2] Owner-occupied housing ("ejerboliger") consists of dwellings occupied by the owner himself.

[3] Social housing ("almene boliger") is constructed and run by social housing organizations. The term "social housing" is a collective designation for three different types of housing: social family dwellings, social dwellings for the elderly and social dwellings for the young. Social housing for the elderly may, however, also be constructed and run by the Danish municipalities or regions (these two types are categorized as publicly owned rented housing) and by independent organizations (categorized as privately owned rented housing).

[4] Cooperative housing ("andelsboliger") consists of apartments or houses in a cooperative housing society. A member buys a share of the society thus causing occupancy of a dwelling in the association. Cooperative housing is to some degree similar to owner-occupied housing; however, pricing of cooperative housing is not free (as it is for owner-occupied housing).

[5] Publicly owned rented housing ("offentlige udlejningsboliger") consists of housing owned by the municipalities, regions or the state that are rented out to individuals. These dwellings are typically targeted at certain groups of individuals, e.g. young people, disabled individuals or the elderly.

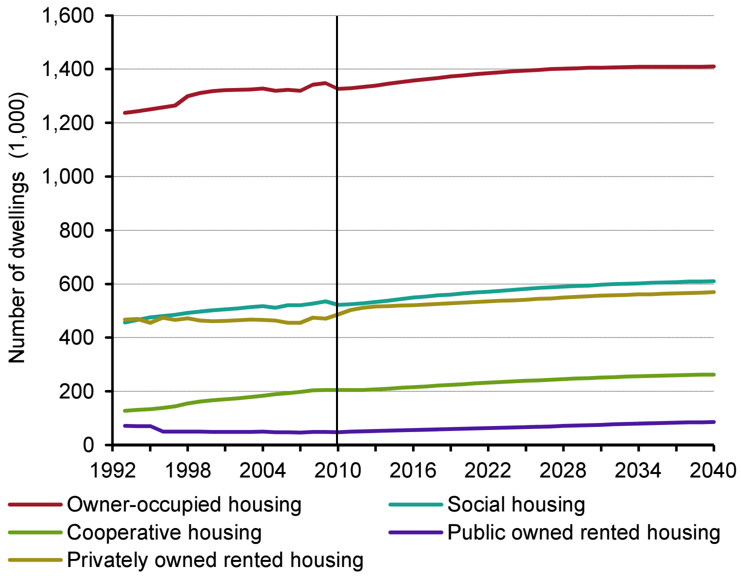
[6] Privately owned rented housing ("private udlejningsboliger") consists of housing owned by private individuals, companies or independent institutions that are rented out. This includes e.g. dwellings in traditional rental properties and sublet owner-occupied housing.

After 2010 demand for each of the five types of housing is expected to grow. Demand for owner-occupied housing, social housing and privately owned rented housing is expected to grow with approximately 85,000 units in total for these three types of dwellings between 2010 and 2040. During the same period, demand for cooperative housing is expected to grow by slightly less than 58,000 dwellings and publicly owned rented housing by slightly more than 38,000 dwellings. Our model thus predicts that the increase in demand for rented housing will be larger than that for owner-occupied housing. Owner-occupied housing will experience a decrease in its share of total housing, going from 51.9 percent in 2010 to 48.0 percent in 2040.

The fact that owner-occupied housing is expected to exhibit a decreasing share of overall housing is primarily caused by three factors that explain future changes in the demand for specific types of housing. Firstly, a considerable ageing of the population is expected, thereby causing a larger share of the population to consist of elderly people. Secondly, a larger share of the population will be living as singles due to the changing pattern of cohabitation. Thirdly, the model predicts that a larger share of the population will be living in the larger urban areas surrounding Copenhagen and in Eastern Jutland. These factors all point to an increasing demand for rented housing during the next three decades.

The ageing of the population mainly causes an increase in demand for publicly owned rented housing and social housing as these housing types mostly consist of senior homes. The changing pattern of cohabitation and the gravitation towards urban areas increase demand mainly for privately owned rented housing and cooperative housing since these housing types are the most common among singe-adult households and in urban areas.

Figure 5. Number of dwellings in Denmark by type, 1993–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

In a further division of housing demand, dwellings are defined according to their physical use. The most common housing categories are detached houses[7], terraced houses[8] (including linked

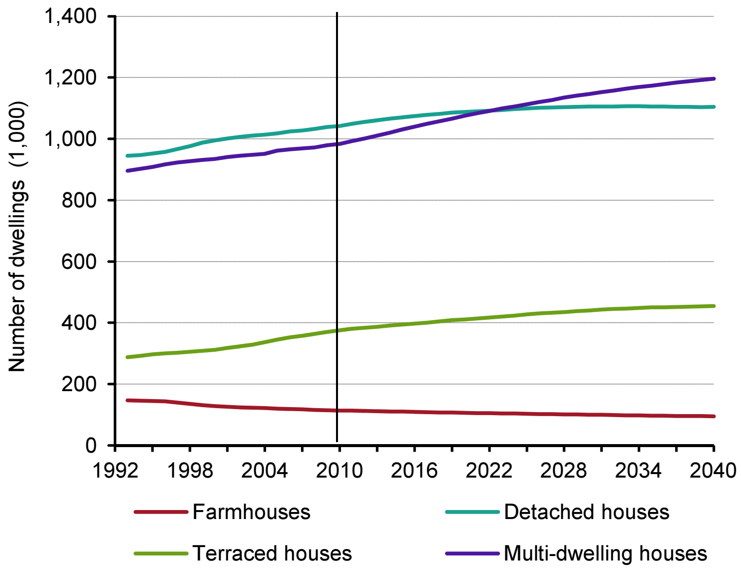
[7] A detached house ("parcelhus") is built independently from other houses and has its own garden. A detached house is intended for housing one family and typically has one or two floors.

[8] A terraced house, linked house or double house ("række-, kæde- eller dobbelthus") is a house in a property consisting of several independent housing units. Typically, such a property contains a row of identical or mirror-image houses that share side walls. Terraced

houses and double houses), multi-dwelling houses[9] and farmhouses[10]. In total, these four categories comprise more than 97 percent of all dwellings in 2010. The remaining stock of dwellings consists of student housing, other residential buildings, properties for commercial use, residential institutions[11] and holiday houses[12].

Figure 6 displays housing demand until 2040 by category where we see an increasing demand for detached houses, terraced houses and multi-dwelling houses while the demand for farmhouses decreases. This continues the tendency observed during the historical period. In the period 2010–2040, the demand for detached houses is expected to grow by 62,500. This is caused by an increase in overall housing demand along with the expectation that households will live in detached houses for a longer period of their life as longevity increases. Between 2010 and 2040 the demand for multi-dwelling houses and terraced houses is expected to grow by approximately 215,000 and 80,000, respectively. This is the result of an increasing concentration in larger urban areas where these categories are predominant. In addition, population growth is especially pronounced among individuals aged 65 and older where a disproportionately large share of households live in housing in these categories. As in the historical period, the demand for farmhouses is expected to decrease in future years, exhibiting an overall decrease of approximately 19,000 over the period 2010–2040.

Figure 6. Number of dwellings in Denmark by category, 1993–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *The figure shows the four most common types of dwellings which in total formed approximately 97 percent of the total stock of dwellings in 2010. Student housing, other residential buildings, properties for commercial use, residential institutions and holiday houses are omitted from the figure. The vertical line indicates the shift between historical data and forecast.*

houses are therefore characterized by a horizontal separation between housing units. There will typically be a smaller garden associated with each dwelling, and each unit is intended for housing one family.

[9] A multi-dwelling house ("etagebolig") is a dwelling in a property where multiple separate housing units are contained within one building. Each unit is intended for housing one family. A common form is a flat in an apartment building. A multi-dwelling house is characterized by a vertical separation between housing units. There can be multiple housing units on each floor and there are often multiple floors.

[10] A farmhouse ("stuehus til landbrugsejendom") is a general term for the main residential building of a farm. It is intended for housing one family and typically has one floor. It can either be connected to one or more barns to form a courtyard or be a separate building.

[11] A residential institution ("døgninstitution") is a home targeted at e.g. children or young people, weak or mentally ill people, or the elderly. In 2010, 19 percent of residents at residential institutions were 0–20 years old and 39 percent were older than the retirement age (65 years).

[12] A holiday house ("fritidshus") is a house built as a summer home that has been approved for permanent habitation.

In summary, our model predicts the demand for detached houses to increase by less than the increase in demand for terraced houses and multi-dwelling houses. The share of the total stock of dwellings consisting of detached houses is therefore expected to decrease from 40.7 percent in 2010 to 37.6 percent in 2040 while multi-dwelling houses will account for an increasing share of the total stock of dwellings. Until 2040 farmhouses' share of the total stock of dwellings will fall by 1.1 percentage points. This is matched by a corresponding increase of terraced share of the total housing stock.

1. Introduction

The long-run development on the housing market is mainly determined by the housing demand. In the very short run, the supply of housing is fixed at the level of the existing housing stock. Consequently, a change in demand will reveal itself through price changes in the market for privately owned housing and through the length of the waiting lists or the level of rents in the market for rented housing. In the longer run, the supply of housing will adjust to demand through construction of new housing or demolition of existing housing. For example, changing patterns of cohabitation and a general increase in wealth meant that the Danish housing demand increased during the end of the 1960s and 1970s. An increase in demand meant that the number of completed dwellings in Denmark hit a historical high in the years 1969–1974. So, an increase in demand meant a rise in housing stock[13].

In the long run, a forecast of the housing demand will give an estimate of the future development of the housing stock, i.e. the development of the number of dwellings, including the type of dwellings, size, geographic location, etc.

The development in housing demand is interesting, because it gives an indication of the need to build new housing for the years to come. Furthermore, a projection of the housing demand can identify new tendencies on the housing market in due time, before they occur. When it typically takes a relatively long time to plan and execute changes in the housing stock, it is relevant to have an indicator for the long-run development. Further, the decision makers can use a forecast of the housing stock to react on the expected development, including changes that can influence the development.

In this report, the housing demand in Denmark is forecasted on the basis of the demographic development including cohabitation pattern, and movements between dwellings describe the housing behaviour. In the forecast, we find the number of dwellings necessary if there is to be one dwelling for each household. It is often called *the potential housing demand.*

In the short run, the housing demand will be determined from factors such as disposable income, level of the interest rate, the price of existing housing, the general price level and inflation. For example, the interest level will affect the financing cost of house purchases, so ceteris paribus a higher interest rate will lower the demand for privately owned housing. In addition, psychological aspects can also have an effect on the housing demand in the short run.

In the long run, the housing demand will to a larger extend be determined by the demographic development. The size and age distribution of the population, the cohabitation patterns and the educational background of the population are examples of factors with a large influence on the long-run demand for housing. As an example, an increase in the number of elderly people will result in an increase in demand for types of housing suitable for the elderly. Likewise, an increase in the number of students will cause an increase in demand for housing suitable for students, this demand typically being for smaller apartments in larger urban areas.

The demographic development is a key driver of the future housing demand. DREAM conducts annual national projections of the Danish population distributed on gender, age, origin, education

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[13] A part of the explanation of the large number of completed dwellings during this period was also the announcement of removal of tax refunds on housing construction. Building activities rose just prior to the removal, so any construction work would be subject to tax refund.

and socioeconomic status[14]. The purpose of this report is to develop a model that forecasts the long-term regional housing demand in Denmark. It imposes several requirements to the population projection, which is forming the basis of this forecast of the housing demand. Firstly, there is a need for a regional population projection for the reasons of regional differences on the housing market. Secondly, there is a need to project the population on a household level, as it is households, who as entities demand dwellings. Therefore, the model shall be able to project household structures. For example, the number of children in a household has great influence on what type of dwelling the household require. Families with children typically require a larger dwelling than families without children, as they often wish for a dwelling with an outdoor area or garden.

To be able to forecast the Danish housing demand, a new population projection is developed, resulting in a regional forecast of the population divided into households. The development in the number of household in each province indicates the development in the overall housing demand in the province, when each household require just one dwelling. The characteristics of the households such as age and number of children indicates the development in demand for certain housing types, when senior households for example require a smaller rental home, and households with children typically require a detached house, which normally would be an owner-occupied house.

The housing demand is projected to the year 2040 with an individual based microsimulation model, which models incidents and behaviour with basis in an initial population and housing stock of 2010 plus transition probabilities calculated on the basis of a historical period. The data consists of registry data on an annual basis for the full population of people and housing in Denmark. The model consists of a demographic module and a housing module.

The demographic module forecasts the household structure of the Danish population one year at a time. In the microsimulation model persons and families are exposed to a number of possible events in each year. These events include fundamental demographic events (i.e. number of births, number of deaths, migration and change of citizenship), socioeconomic events (i.e. educational status and labour market affiliation) as well as household specific events (i.e. the formation of couples, the break-up of couples and the event of a child leaving the parental home). The events are simulated on the basis of exogenous transition probabilities calculated from data covering actual events in the period 2008–2010.

In the housing module, the housing demand is forecasted on the basis of the household structure as well as the behaviour of the households on the housing market. Housing supply is not included. The housing demand constitutes the number of dwellings, which the households is willing to purchase or rent at the existing prices. The household's housing behaviour is modelled by movements between dwellings and a choice of dwelling the household moves to. The microsimulation model is used to simulate the behaviour based on exogenous transitional probabilities, which is calculated on movements in the 2000–2010 period. The transition probabilities are split between movement and choice of dwelling probabilities. Movements are the outcome of a binary choice: Households can either choose to move or stay where they already live. The choice of dwelling is the outcome of a set of discrete choices: The households choose the location of the dwelling (province and town size), owner and rental status (housing type), category (physical use), area (the size of dwelling) and year of construction (the dwelling's age).

[14] The purpose of the DREAM system is to evaluate the long-term development of public finances in Denmark. The DREAM model system consists of three pre-models and the economic model DREAM ("Danish Rational Economic Agents Model"). The pre-models form national projections and consist of a population projection model, an education projection model and a socioeconomic projection. The three pre-models runs independently of each other. However, the population projection provides input data for the education projection, which in turn provide input data to the socioeconomic projection (www.dreammodel.dk).

Movement and the choice of dwelling probabilities is estimated as decision trees, which are capable of classifying an outcome on the basis of the characteristics of the household and the dwelling. Decision trees are a statistical method for splitting the data basis within groups. For example, you begin by splitting the households by type of household (couples and singles), then splitting each group by age etc. The split of lesser and lesser groups lead to *terminal groups*, where the households are homogenous in relation to the outcome. Each terminal group must contain households with approximately same housing behaviour, while the terminal groups distinguish themselves of being characterized by different housing behaviour. Within each terminal group, a transitional probability is calculated for the outcome, i.e. a movement or choice of dwelling probability.

The projection uses an implicit assumption that the long-run housing demand is independent of the actual housing supply. Consequently in the long term, the housing market will create a supply, which fully meets the demand. Another central assumption is obtained by applying the historical transition probabilities as a measure of households' true preferences. The observed housing behaviour does not necessarily reflect the household's true preferences for choice of dwelling, since the observed preferences are limited by a number of factors within the historical period (for example housing supply, housing prices, interest level etc.[15]). Thus, the future behaviour is simulated from retention of the tax and interest levels of the historical period, the regulation of rented housing, level of unemployment, inflation etc., influencing the housing behaviour[16]. The time period used to estimate the housing behaviour spans over eleven years in order to control for any cyclical fluctuations in the behaviour.

In the forecast, it is assumed that if a person's housing behaviour depends on age this behaviour will not be influenced by an expected rise in life expectancy within the society. Therefore, it is not included, that a rise in life expectancy can lead to, for example a postponement in the need for care for the elderly due to a longer life expectancy. This would lead to a postponement in the need for housing for the elderly to a point later in life than represented in the data.

It can pose a problem to estimate the models transition probabilities on a relatively short historical period, if this period stands out from "normality". The transitional probabilities in the demographic module are calculated on the basis of events in the three latest data years, which generally has been heavily influenced by the on-going crisis. To the extent the crisis has had a temporary effect to events like birth rates, migration, the formation and break-up of couples etc., this can affect the results of the forecast. This is tried solved by letting the birth rate in the model follow DREAM's national population projection, where the fertility quotient converges towards a long-run level. The other demographic events do not appear to be significantly affected by the crisis. In the housing module, movement and choice of dwelling probabilities is estimated over an eleven-year period to control any cyclical fluctuations in the behaviour. However, to estimate the housing behaviour on the basis of a long-term period is not without complications. To the extent the housing behaviour has chanced within the historical period, you risk to continue tendencies in the forecast, which are no longer applicable.

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[15] Imagine for example, that there is a large demand for detached houses in central Copenhagen. But in practice, the supply is extremely limited, which results in high housing prices on detached houses in the city centre. This will cause some households, who are looking for a dwelling near the centre of Copenhagen, to buy a dwelling in the surrounding municipalities instead. Therefore, the historical data don't show the households true preferences. Instead, we observe the households choice in the given situation (with the given housing cost, etc.). In the projection, the future behaviour is assumed to be the same as in the historical period. This implicitly implies that the factors which affect a household's choice of dwelling will be the same in the projection as in the historical period.

[16] Meaning a retention of all the elements in the housing costs ("user costs"), which express the household's cost of living in the actual dwelling. For owner-occupied housing, the cost is expressed by capital costs, property tax, operating and maintenance costs, inflation and expected return. For rented housing the cost is expressed with the rent.

This report is initiated by a summary, wherein the results of the forecast of the housing demand is presented. The summary is followed by this introduction in chapter 1. Then the report documents the methods and data basis of the forecast. Chapter 2 gives an explanation of the demographic module, while chapter 3 explains the housing module. The transition probabilities are presented continuously throughout chapter 2 and 3.

Together, the demographic module and the housing module form a process for the forecast. This process uses a number of calculation preconditions and assumptions about the future. In chapter 4, the results of the forecast are presented. The chapter begins with the regional population projection broken down by age, gender, origin, education and socioeconomic status (chapter 4.1). Then the forecast of the regional household structure is treated (chapter 4.2), followed by the presentation of the forecast of housing demand on a national level (chapter 4.3). On the basis of the development in the total housing demand, we can then estimate how large housing investments are necessary to meet the housing demand (chapter 4.4). The report is finished by a conclusion in chapter 5.

2. Household Structure

The modelling of the household structure is an essential element in the analysis of the future housing demand. The development of the number of households indicates the development in the total housing demand, when each household demands just one dwelling[17]. The development in the household composition indicates the development in demand for certain housing characteristics. For example, families with children will demand larger dwellings than single adults. It is therefore necessary to know the future development in the number of single people and couples, the number of children per household and eventual regional differences in the household structure.

An exact modelling of the future household structure has not previously been conducted in Denmark. However, forecasts of the housing demand by the Ølgård committee (Ministry of Housing (1988)) and in the Ministry of Social Affairs (2006) are based on a population projection and relatively simple assumptions of the cohabitation frequency[18]. Instead, a microsimulation model is established in the present model's demographic module; a microsimulation model which projects the Danish household structure on a family and persons level. The Danish population in beginning of year 2010 forms the basis for this model, divided after the observed household structure. The population is projected one year at a time on the basis of transitional probabilities, which determine the behaviour and events for each family or person. For example, a single adult will by a certain probability form a couple with another single, and a couple will by a certain probability be split up. The transitional probabilities are calculated for the period 2008–2010. As a rule, the probabilities in the projection are constant and therefore carry over tendencies that are observed in the historical period. Though, certain probabilities vary over time. This makes it possible to carry over a historical trend in the probabilities through the projection period (made for death frequencies) or to let the probabilities converge towards a long-run level, which are different from the tendencies of recent years (made for fertility quotient).

In chapter 2.1, we will give an introduction to the microsimulation model, which is used to forecast the household structure and the housing demand. In chapter 2.2, we will then describe the structure of the model. The model is based on an initial population, which is projected by several possible events that can occur in each of the periods of the model. For example, this applies to birth, death, the formation of couples (if single), the break-up of couples (if couple) etc. Eventually, three chapters follow, which will explain, how each of these types of events are modelled.

2.1. Microsimulation

The projection of the household structure is carried out using a microsimulation model. Introduced in Orcutt (1957), the method suggest a model of interacting individuals (for examples households, persons or companies) to address some of the shortcomings of macroeconomic models. The idea is that the behaviour of individuals is modelled on micro-level then to be aggregated up to express the behaviour of the overall economic system. Microsimulation models are also called micro-founded models or microfoundations.

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[17] However, there is no one-to-one connection between the number of families and number of dwellings, because certain dwellings are inhabited by more than one family, some families own several dwellings, as well as you find persons without a dwelling and because some dwellings are uninhabited.

[18] The cohabitation frequency indicates the percentage of a group, who lives as couples.

Basically, we distinguish between individual based and group (or cell) based models, which each has its strengths and weaknesses. Group based models are relatively simple to construct, but are limited in their ability to describe disaggregated problems. In contrast, individual based models are typically more time consuming to build but can in return describe more detailed problems.

DREAM's national population projection[19] is an example of a group based model, where the population is divided by gender, age and origin. An event (the number of deaths for example) is modelled by combining a group (for example the number of 60-year-old males, N) with a proportion or probability (for example the death frequency among 60-year-old males, μ). The number of males who die as 60-year-old, D, is then modelled by multiplying the number of 60-year-old males with the death frequency:

$$D = \mu \cdot N \tag{2.1}$$

The problem by this modelling strategy is that the number of groups can be too large (the problem is often referred to as "the curse of dimensionality"). If the population is divided into 120 ages, to genders, five types of origin and 50 time periods, then you have 120 · 2 · 5 · 50 = 60.000 groups. Assume the population is projected on a regional level by further dividing it into eleven provinces. The number of groups then becomes 60.000 · 11 = 660.000 groups. The size of models explodes, when more characteristics are added, which to a large extent limits the level of detail and potential for development of the model.

The same principles do not apply for an individual based model. Denmark is inhabited by approximately 5.5 million people. This apply no matter how detailed you construct your model. It is significantly more complicated to develop an individual based model, but when it has been developed, its' size is more or less fixed. Therefore, the individual based model has a considerably larger potential for development.

Individual models are based on *Monte Carlo Simulation*. Assuming same problem as above, that 60-year-old males all have the death probability μ. All N individuals will therefore die with the probability μ. This is done randomly by letting the computer draw a number between 0 and 1. If the number is less than μ, the individual dies. This technique is often referred to as Monte Carlo Simulation. If you add up how many of the total number of people who die, you will see that:

$$D \cong \mu \cdot N \tag{2.2}$$

The relation applies exact, if the number of individuals N is sufficiently large (the law of large numbers, LLN). However, if N is small, the relation only applies approximately. This uncertainty about Monte Carlo Simulation is one of the disadvantages of individual based models. It is important to keep in mind, that model results concerning highly detailed capabilities is vitiated by considerable uncertainty. You could say it is the cost for avoiding "the curse of dimensionality".

The essential part of a microsimulation model is therefore, that it is based on single individuals rather than groups of individuals. In microsimulation, we distinguish between static and dynamic models. In static models, the behavioural patterns among individuals are constant over time, while an individual's behaviour in a dynamic model will change over time.

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[19] DREAM develops and maintains the official Danish population projection. The projection of the development in the overall Danish population is published by Statistics Denmark and is used by ministries, NGOs, etc. The population projection is one of the so-called pre-models to the macroeconomic model DREAM ("Danish Rational Economic Agents Model"). The national population projection indicates the development in the overall Danish population by gender, age and origin.

Microsimulation is based on an initial population of individuals for whom all characteristics wished to be included in the simulation are available. In a projection of the household structure typical characteristics will be age, gender, education level, family type etc. The simulation projects the initial population in discrete time, i.e. time intervals measured for one day, one month or one year duration for example. During the simulation, characteristics are updated for each individual in the population as time progress. The update is done by exposing each individual for a set of possible events during each time interval. For example, this could be to start or complete an education, get married or divorced, have a baby etc. To determine if an event occurs, each individual is asked a yes-no question, depending on the characteristics of that individual. For example, this could be asking a single 30-year-old female, if she will find a partner during the following year.

Whether the answer is "yes" is randomly determined with *a transitional probability*, that from the individual's characteristics indicates how likely the event is to occur. In the example above, the probability will indicate, how likely it is, that a single 30-year-old female will find a partner during the following year. Transitional probabilities that indicate if an individual will experience a certain event within a given year are usually based on historical observations. In this example, a single male is required to answer "yes" to the question, whether he will find a partner, whereby these two will form a couple[20]. In the following period, the female will not be asked the same questions, because now she is a part of a couple. However, if the event does not occur, the individual will be asked the same questions again in the following period. In this way, it is possible to simulate the remaining life course of all individuals in the initial population and then create long-run forecasts.

2.1.1. Transitional Probabilities

In microsimulation models, individuals' behaviour is determined by *transitional probabilities*. A transitional probability defines the probability distribution for what each individual can do or become subject to in a given situation. The transitional probability depends on the characteristics of the individual and will typically be calculated on the basis of behaviour observed in historical data. If a trend is observed in the individuals' behaviour in the historical period, this trend can continue in the applied transitional probabilities, whereby you achieve a dynamic microsimulation model.

There are different ways to calculate transitional probabilities. Firstly, we have what you could call *the raw transitional probabilities.* Here, we calculate the probability distributions directly from data. A simple example could be to calculate the transitional probabilities for when children and young people leave the parental home: From an external source, we have data of the number of people who move out into their own home during a given period of time. In the beginning of this period, we have a population of a total of 200 young people living at home, whereof 100 are male and 100 are female. The data tells us, that 67 of the males move out of their parental home during the period, while 22 of the females leave their parental home. We therefore calculate the probability for a male leaving the parental home to 67 percent. Similarly, we calculate the probability for a female leaving the parental home to 22 percent. These are the raw probabilities calculated directly from data without any form of correction. The advantage of this approach is that "the data get to speak". The disadvantage is that data easily can become too "weak", i.e. that the probability is calculated using so few observations, that there is a significant uncertainty of the result. An example of this: Assume the total population comprised 100 male and 2 females instead. 67 of males leave their parental home during the period, and 1 of the females leave the

[20] Alternatively, a couple can comprise two people of the same gender. This will occur to the same extent, that it is observed in the historical data.

parental home. From this, the raw probabilities for leaving your parental home become 67 percent for males and 50 percent for females. But since the number of females in the data is only 2, the result for the females is very uncertain.

In the example above, we have one explaining discrete variable (gender) with two elements (males, females). Often you will need more explaining variables, with many more elements. As a consequence, weak data will be a problem in virtually every analysis. To solve this problem, we use a technology called CTREE (Conditional Inference Tree), cf. Hothorn (2006). The idea of this method is: You only distinguish between the elements in an explaining variable, if it makes a statistically significant difference. In the example above, CTREE will ask the question: Is 67 percent and 50 percent significantly different, when you only count 2 females? This is determined by a statistical test. If the answer is no, the two elements “males” and “females” are merged into one group, and a common probability is calculated[21]. When we have many explaining variables, the calculation becomes too heavy to assess all possible combinations (see chapter 3 for a closer study on decision trees).

2.2. Building the Microsimulation Model

The household structure is projected using a microsimulation model, which project the Danish household structure on a family and person level. A microsimulation model takes basis in an initial population, which is projected one year at the time on the basis of behaviour and events. As an example, an event could be that a family emigrates, or a person dies.

Section 2.2.1 will describe, how the models initial population is formed and which characteristics are included in the projection. Section 2.2.2 will describe the projection method, where the populations’ behaviour is simulated from a set of possible event occurring in each projection year.

2.2.1. Initial Population and Objective Structure

Basically, the microsimulation model works as following. First, we load the initial population of the reference year, which consist of all 5,534,738 Danes in beginning of year 2010. For each person, we register personal characteristics such as gender, age, origin etc. Furthermore, a unique identification of how each person is related to a family as well as this person’s status in the family as an adult or child living at home is also necessary[22]. For each family, a dwelling is registered, which is described with characteristics like dwelling type, location, size etc. From this, we build a snapshot of the household structure in the reference year for a total of 2,815,778 families.

For each person in the population, we form a person-object, while we form a family-object and a dwelling-object for each family[23,24]. The person-object contains a person’s characteristics. These are dynamic and are updated as the person gets older, changes educational status etc. The dwelling-object contains characteristics for the dwelling of each family. This object is static in the

[21] In this case, the common probability to leave the parental home becomes (67 + 1) / (100 + 2) = 66.67 percent.

[22] Children and young people living at home are in the age between 0–29 years. Young people between 0–24 years are living away from home, if they are registered as children not living at their parental home according to the definition of the E-family type term by Statistics Denmark. Young people in the ages between 25–29 years are not living at their parental home if they have another home address than both their parents. It is assumed, that everyone has moved out of their parental home by the age of 30.

[23] With an object, we mean a collection of data (or collection of other objects). The object is a way of keeping track of all the information that is attached to a person, a family or a dwelling. For example, a person-object will contain all the characteristics for that person, i.e. the person’s age, gender, origin, nationality, time of residence plus information on highest completed and current education. When you form a new person-object, a person is added to the model population and by the formation you indicate this person’s characteristics. The objects are dynamic, meaning they can be updated during the projection. For example, you can update a person’s age in every projection year or the person’s educational status if this person begins a new education.

[24] The person- and dwelling-object contains characteristics of a single person (age, gender, origin etc.) or dwelling (dwelling type, size, construction year etc.) respectively. The family-object consists of other objects, since the family-object contains the persons within the family (person-objects) and the dwelling the family lives in (the dwelling-object).

sense that a dwelling's characteristics cannot change over time[25]. The family-object keeps track of persons and dwellings, since a family-object consists of persons in the same family living in the same dwelling (persons are divided into adults and children still living at home). The family-object also contains the dwelling, where the family lives. The family-object is dynamic, since the number of persons in the family changes, if a couple breaks up or to persons forms a new couple, by birth, immigration, or if a child living at home moves out. The dwelling attached to a family-object can also change, if the family decides to move to a new dwelling.

The initial population is constructed by the DREAM group for this purpose by merging a number of Statistics Denmark's central personal records[26], where a personal identification number uniquely characterizes each person. Data is register based and provided by the Science Service Act under Statistics Denmark ("*Forskerserviceordningen"*) that is a system where researchers can buy access to detailed individual data from a number of key records. The transitional probabilities used in the demographic module are constructed on the basis of a panel data set, which contains observations on a yearly basis of the total Danish population.

Characteristics in person-objects

The central object for the simulation model is *the family*[27]. The individual family is assumed to consist of *a group of adults*, *a group of children* and *a dwelling*. The persons in the two groups are defined by characteristics such as age, gender, origin, education and socioeconomic status. **Table** 2.1 contains a list of these characteristics that is a part of the population projection.

Table 2.1. List of personal characteristics.

Personal characteristics		Value set
Age		1-year age levels 0–120 year
Gender		Male, female
Origin	Type	Immigrant, descendant, the rest
	Country of origin	Western, non-western
Danish citizenship		Yes, no
Time of residence		1-year steps from age 0 and up
Highest completed education		12 educational groups, see Table 2.2
Ongoing education		12 educational groups, see Table 2.2
Academic year on ongoing education		1-year steps from 1 year and up
Socioeconomic status		7 conditions, see Table 2.3

Source: Own creation.

[25] In real life, certain dwelling-characteristics can change over a short period of time, which among other things apply for a dwellings size that can be modified by a construction extension, for example. The type or category of a dwelling can also change to a certain degree, when rental houses for example can be transformed into cooperative or owner-occupied housing. This will be ignored in the projection.

[26] The primary source is the population statistics, which is a full census of the population residing in Denmark by January 1st. This census is supplied with select information from the statistics for families and living conditions, the family statistics, the population by status of education plus the register based labour force statistics (RAS).

[27] A family is defined from Statistics Denmark's E-family type concept, which however is modified by recognizing children and young people living at home until they are 29 years old (Statistics Denmark recognize children living at home until they are 24). Meaning that the persons in a family living at the same address define a family, and that the family consists of one single adult or one couple (two adults). Children living at home are included if they live at the same address as at least one of their parents, are under 30 years old and do not have children of their own, are nor married and are not a part of a couple themselves.

A person's characteristics follows similar terms from DREAM's per-models[28] to a wide extend. This is a set of models that among others comprise of a population projection, which projects the development in the total Danish population and an educational projection, which estimates the future educational level of the future population. The result of these projections is used in the economic model DREAM (Danish Rational Economic Agents Model), where the population development is considered exogenously given.

Origin is defined by distinguishing between immigrants, descendants and the rest of the population, where the latter group often is referred to as persons of Danish origin. Immigrants are persons, who are born abroad by parents, which both are foreign citizens or themselves born abroad. Descendants is defined as persons, who are born in Denmark by parents, who are neither Danish citizens or born in Denmark. As illustrated, a citizenship is central to these definitions, and this explains why citizenship is included in the analysis. According to Statistics Denmark's definition, a person's country of origin is grouped by either western or non-western countries, accordingly[29].

Table 2.2. List of educational groups.

Educational group	Potential grouping
Elementary school (to and including 9th grade) 10th grade	Elementary school
General upper secondary education Upper secondary vocational education	Upper secondary education
Vocational education	Vocational education
Short-cycle higher education	Short-cycle higher education
Professional bachelor Medium-cycle higher education University bachelor	Medium-cycle higher education
Master degree, 5 years (undivided) Master degree, 2 years (divided) Ph.D.	Long-cycle higher education

Source: *UNI•C's educational grouping on main groups.*

Note: *In Denmark, long-term university courses are split into a 3-year bachelor degree, which may be followed by a 2-year master degree. After the master's program you can read a 3-year Ph.D. program. Previously, a master degree was a 5-year education. The change from a 5-year (undivided) master degree to a 3-year (university) bachelor and a 2-year (divided) master degree are implemented on the Danish universities in the period 1993–2005. Therefore, only a few students still study on a 5-year (undivided) master degree.*

Typically, educational level is measured from the term "highest completed education". This implies an educational ranking on a scale corresponding to the order in Table 2.2, where the highest ranked education is placed at the bottom. For each individual person, the highest completed education is decisive for that persons "level". For example, if you have not completed

[28] DREAM's pre-models form national projections and consist of a population projection model, an education projection model and a socioeconomic projection. The three pre-models runs independently of each other. However, the population projection provides input data for the education projection, which in turn provide input data to the socioeconomic projection (www.dreammodel.dk).

[29] "Western countries" includes all 27 EU-countries including Andorra, Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland, The Vatican State, Canada, USA, Australia and New Zealand. All other countries make up the "non-western countries" group.

a long-cycle higher education, this does not count no matter how many years you might have studied.

Highest completed education is determined by the educational groups in DREAM's education projection[30], see Table 2.2. For persons in education, we register what education that individual person is taking. Furthermore, it is registered what academic year the person is at, as this is significant for that person's further progress in the educational system. As the number of educational groups is relatively large, we make a further grouping consisting of six levels. This grouping is defined as in Table 2.2.

Finally, we determine the socioeconomic status according to a person's relation to the labour market (in the labour force, undergoing education, temporarily outside the labour force, resigned etc.). There is accordance between a person's socioeconomic status as a student, and if the person is undergoing an education (a person's path through the educational system is modelled individually). A person's labour market affiliation is determined from seven groups as shown in Table 2.3.

Table 2.3. List of socioeconomic status.

Labour market status group	Persons in group
Labour force	Employed (excluding students) and unemployed
Students	All persons undergoing education
Momentarily outside the labour force	Maternity leave, sickness benefits, labour market leave
Temporarily outside the labour force[1]	Social benefits and social activation, retraining etc.
Early retirement[2]	Disability pension
Retirement[3]	Voluntary early retirement, public age pension
Others outside the labour force[4]	Outside the labour force and not received social benefits

Source: Own creation.

Note 1: Temporarily outside the labour force reflects activation ("aktivering"), upgrading and training ("opkvalificering") and social security ("ikke-arbejdsmarkedsparat kontanthjælp"). Persons under those actions return in lesser degree to the labour force than persons momentarily outside.

Note 2: Early retirement exclusively include people on disability pension ("førtidspension"). This is an allowance granted to persons whose working capacity is permanently reduced. You are allowed to work beside disability pension, why a disability pensioner may transfer to the labour force. A person can also leave disability pension if his or her working capacity are significantly improved so the person can support themselves through persistent work.

Note 3: The category includes people on voluntary early retirement ("efterløn"), flex assistance ("fleksydelse") or public age pension ("folkepension") which has voluntarily left the labour market. These people can still work in a limited scope and therefore be a part of the labour force.

Note 4: Others outside the labour force are individuals who are not in the labour force and not receiving any social benefits. This could be children or housewives, for example.

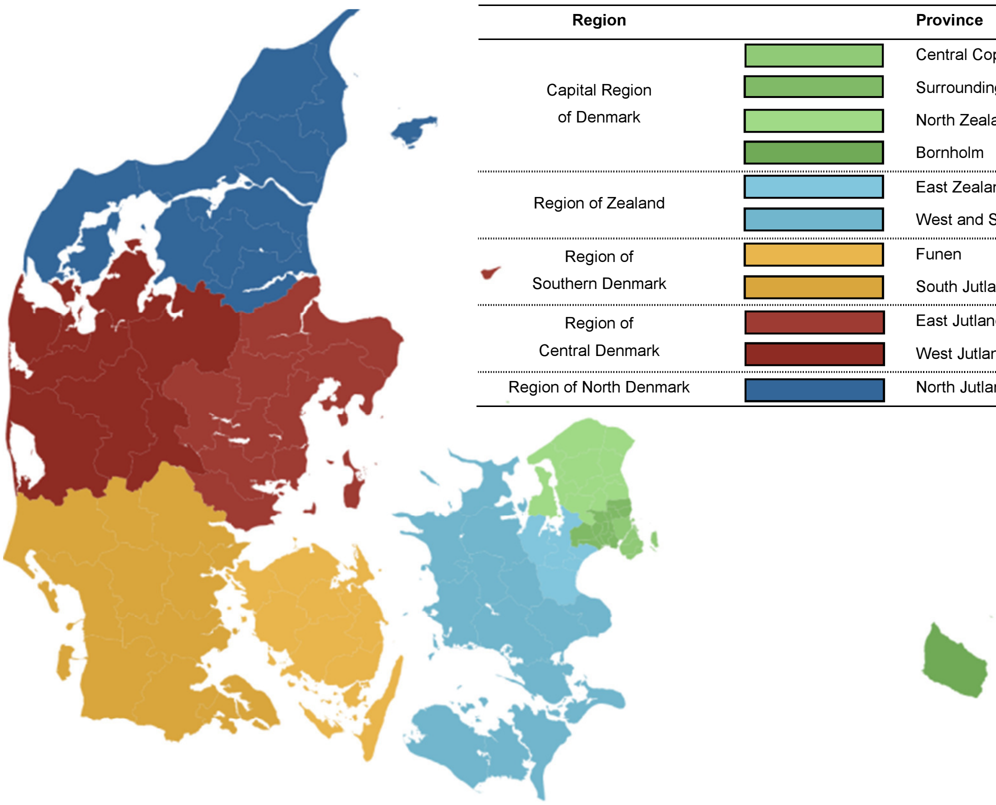
Characteristics in the dwelling-object

A dwelling is characterized by location (province and city size), ownership and rental status (housing type), category (physical use), area (dwelling size) and construction year (dwelling age). The provinces are depicted in Figure 2.1 and form a basis for the regional population projection. All dwelling characteristics apart from province will be described in detail in chapter 3.1.

[30] DREAM's education projection model is based on a projection of the total Danish population by gender, age and origin. In the projection, the population is further divided by highest completed and ongoing education (and academic year on ongoing education, if in training). The forecast is done by micro-simulation where a person's progress through the educational system is modelled based on transition probabilities. The education projection is one of the so-called pre-models to the macroeconomic model DREAM ("Danish Rational Economic Agents Model").

A family's geographic affiliation is determined from the location of the family's dwelling. The country is divided into eleven provinces corresponding to a subdivision of the five Danish regions[31]. The subdivision into provinces can be seen in Figure 2.1. The Capital Region of Denmark ("*Region Hovedstaden"*) is divided into four provinces (Central Copenhagen, Surrounding Copenhagen, North Zealand and Bornholm). The Region of North Denmark ("*Region Nordjylland"*) is used as one province, while the remaining regions are divided into two. The Region of Zealand ("*Region Sjælland"*) is divided into East Zealand and West and South Zealand. The Region of Southern Denmark ("*Region Syddanmark"*) is divided into Funen and South Jutland. Finally, the Region of Central Denmark ("*Region Midtjylland"*) is divided into East Jutland and West Jutland.

Figure 2.1. Map of provinces in Denmark.



Region	Province
Capital Region of Denmark	Central Copenhagen
	Surrounding Copenhagen
	North Zealand
	Bornholm
Region of Zealand	East Zealand
	West and South Zealand
Region of Southern Denmark	Funen
	South Jutland
Region of Central Denmark	East Jutland
	West Jutland
Region of North Denmark	North Jutland

Source: Statistics Denmark's subdivision of the five Danish regions into eleven provinces.

Characteristics in the family-object

Fundamentally, a family's characteristics are based on person and dwelling characteristics. See Table 2.4 for an overview. The number of years in the present family type is determined for all adults and indicates the number of years, which the family has been given in its present state either as a single individual or as two individuals (a couple). If the number of adults in the family is changed due to a formation or break-up of a couple, the variable is reset. For children living at home, the number of years in the present family type is equal to the person's age.

[31] Denmark is divided into five regions and 98 municipalities. The five regions are the Capital Region of Denmark ("Region Hovedstaden"), the region of Zealand ("Region Sjælland"), the region of Southern Denmark ("Region Sydjylland"), the region of Central Denmark ("Region Midtjylland") and the region of North Denmark ("Region Nordjylland"). The regions have between 0.6 and 1.6 million inhabitants. In terms of acreage, the smallest region is the Capital Region of Denmark covering 2,561 square kilometers while the largest region, the region of Central Denmark, covers 13,142 square kilometers. The division of Denmark into eleven provinces is conducted by Statistics Denmark and is only used for statistical purposes.

By counting the number of children in the family and combining these with the number of adults, you achieve the typical subdivision of family types: Single without children, couples without children, single with one child, couple with one child, single with two children etc.

Table 2.4. List of family characteristics.

Family characteristics	Values
Age	Average age of adults
Number of adults (family type)	1 (single), 2 (couple)
Number of children	0, 1, …, 9, 10
Age of the youngest child in the family	1-year age levels 0–29 year
Number of years in present family type	1-year age levels from 0 years and up
Province	Province of the location of the family's dwelling, see **Figure** 2.1

Source: Own creation.

When the initial population is loaded and all families are formed, the microsimulation will initiate its projection. The initial population is projected one year at a time by letting a set of possible events occur during the following year. The transition probabilities determine, if a given event occur or not. Events can occur either for a single family (for example, moving to a new dwelling, the whole family emigrating etc.) or for a single person in the family (death, child living at home moves out etc.).

2.2.2. Projection and events

The forecast of the initial household structure occur by modelling possible *events* in the family. Basically, we operate with three types of events: *Demographic events* (birth, death etc.), *socioeconomic events* (education and labour market affiliation) and *household specific events* (change of dwelling, formation of couples, breakup of couples, moving out of parental home). Table 2.5 contains a list of events, which are modelled in the forecast of the household structure.

To some extent, the modelling of *the demographic events* draw on analyses, which form the basis for DREAM's national population projection. For various reasons however, it is necessary to increase the level of details in the analyses, which are designed especially for the forecast of the household structure.

Firstly, we should take into account that the microsimulation model is dealing with eleven provinces. There are considerable regional differences in the demographic behaviour, which we want to include in the model. Secondly, we focus on households rather than persons. An example could be the applied fertility quotient. In projections on person level, the number of births is calculated from fertility quotients divided by age. Implicitly, we assumes that the probability for giving birth to a child is this same for all 25-year-old females regardless how many children that particular female has already given birth to. This does not work in a model of the household structure however, as the division of number of children among the families will be wrong. Therefore, it is necessary to include the number of previously born children (parity), if we are to achieve a description of the division of number of children, cf. section 2.3.1.

Table 2.5. List of events.

Type	Event
Demographic events:	Birth
	Death
	Immigration
	Emigration
	Change citizenship (naturalization)
Socioeconomic events:	Change educational status - If not undergoing an education: starting a new education - If undergoing education: drop out, continue or finish education
	Change labour market affiliation
Household specific events:	Formation of couples
	Break-up of couples
	Child living at home moves out of parental home
	Moving to new dwelling

Source: Own creation.

The modelling of *household specific events* is newly developed. In this context, the central elements are modelling of the formation of new couples and break-up of existing couples. Therefore, all couples have a probability to be broken up. Opposite, each year all persons that do not live as couples have a probability to be include in a so-called *matching pool*. At the end of the year, the persons in the matching pool will be matched where a set of characteristics are taken into account. For this purpose, a new method called SBAM (Sparse Biproportionate Adjustment Matching) has been developed. This method is characterized for its speed at matching many persons and by considering many personal characteristics, cf. section 2.5.4.

Socioeconomic events deal with education and labour market affiliation. Persons are characterized by an on-going and a highest completed education. The educational behaviour is based on transitional probabilities from DREAM's education projection, cf. section 2.4.1. Therefore, a person who is not undergoing an education has a probability each year to begin an education. A person who is undergoing an education has a probability each year to drop out of, continue or complete that education. Among other things, for students undergoing an education these probabilities depend on what academic year the student has reached.

An affiliation to the labour market is described by transitional probabilities between seven socioeconomic groups, cf. section 2.4.2. We distinguish between persons in the labour force, students and persons outside the labour force. If a person is outside the labour force, we distinguish whether how probable it is for that persons to return to the labour force. People on maternity leave or sickness benefit will typically return to the labour force after a short period outside. Person's receiving social security, social activation or retraining make up a group where returning to the labour force is relatively less probable. Finally, returning to the labour force is relatively rare for the early retired, voluntarily early retired and people receiving public age pension.

2.3. Demographic Events

Demographic events determine the development in the overall Danish population during the projection period. The development is a consequence of relatively few mechanisms: The population increases due to births and immigration and decreases due deaths and emigration, while the population composition of origin groups changes through achieving Danish citizenship. Each paragraph below describes the modelling of the demographic events that are included in the population projection.

The projection is based on the initial population divided by a number of background characteristics. It is projected one year at the time on the basis of transitional probabilities, which determine if a demographic events occur or not.

Table 2.6 contains a list of how the demographic events are modelled. For two of the events, the probabilities are estimated with a compressed decision tree, where the subdivision is decided on the basis of background characteristics. The compression is conducted using a classification model, which are implemented by the so-called CTREE algorithm. The algorithm is described in detail in chapter 3.2. For two of the other three events, the transitional probabilities are calculated directly from data, we call these observed or raw transitional probabilities. The death probability is estimated by the so-called Lee-Carter method which is a numerical algorithm based on extrapolation. The method is used in mortality forecasting and the basic assumption is that the future development can be described from the historical development

Table 2.6. List of transitional probabilities that determine demographic events.

Event	Estimation model	Background characteristics for probability
Fertility	Observed	Mother's age, province, number of children in the family, age of youngest child in the family, marital status and time
Mortality	Lee-Carter	Age, gender, province, marital status and time
Immigration, single	CTREE	Age, gender, province, origin and children
Immigration, couple	CTREE	Age, gender, province, origin of both adults in the couple and children
Change of citizenship	Observed	Age, gender and origin

Source: *Own creation.*

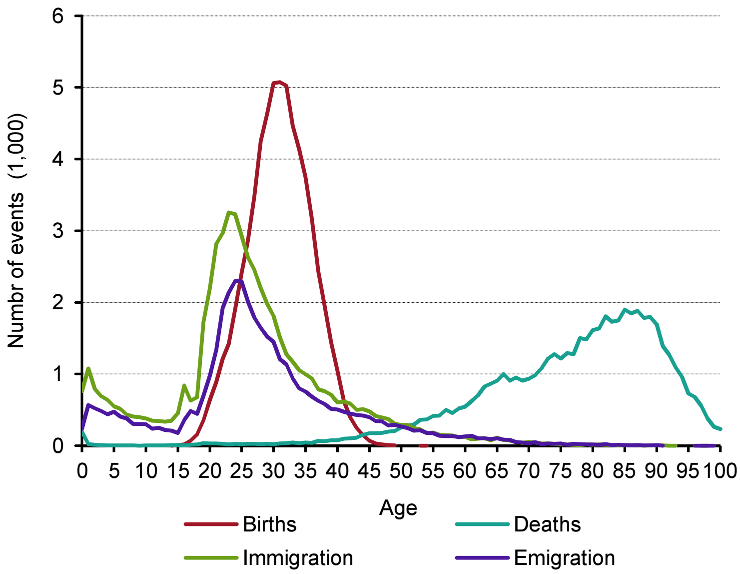
Note: *With observed transitional probabilities, we mean probability distributions, calculated directly from data (raw transitional probabilities). The Lee-Carter model is a numerical algorithm used in mortality forecasting. Trends in mortality are projected for each gender. CTREE is a static method, which automatically can classify any outcome based on the background characteristics. The method is well suited, if there are many combinations of background characteristics, and you risk "weak" data. CTREE is described in detail in chapter 3.2.*

For example, births are determined by raw transitional probabilities. In the beginning of the year, we have a probability for each female in the population telling how likely it is that the female gives birth to one child during the following year. The probability of a birth depends on the following characteristics: The female's age, the province of residence, the number of children the female already has, the age of the youngest child and if the female is a part of a couple or not. Females in couples therefore have a higher probability to give birth than single females, birth is most likely to occur around the female's 30th year and a female will typically give birth to two or three children.

Immigration does not directly depend on the number of persons residing in Denmark and is therefore not estimated by a transitional probability. Instead, we have an exogenous influx of immigrants, whose number and origin composition is determined by DREAM's national population projection, cf. Hansen and Stephensen (2012).

Figure 2.2 shows the age division of persons who experience a demographic event in 2010. The average age of a female giving birth is barely 30 years. Around this age, we see a relatively nice bell-shaped division of the number of births. The number of deaths is under 100 for every age step until the age of 40. We see a small excess mortality for the 0–2 year old. From 40 years and onward, the mortality rate increases steadily. The number of migrations peak in the middle 20s. In most of the age steps, we see a positive net immigration. We take a closer look at these events in the following chapters.

Figure 2.2. Age related number of demographic events, 2010.



Sources: Own calculations based on register data from Statistics Denmark.

Note: Births are divided after the mother's age at the time of birth.

2.3.1. Fertility

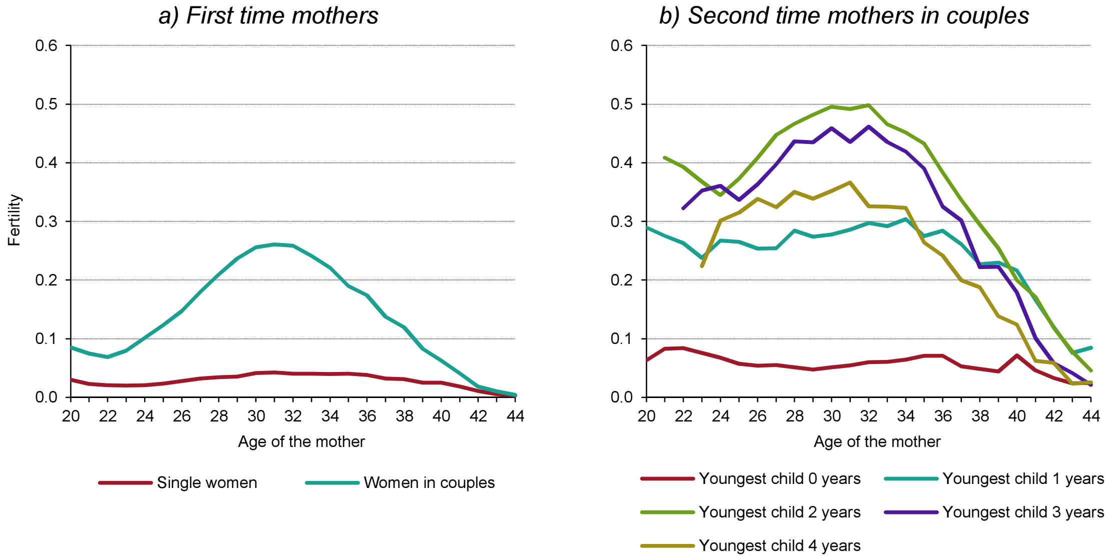
Births are simulated for females between 15 and 49 years by using fertility quotients calculated on the basis of births in the period of 2008–2010. The fertility quotient is assumed to depend on the mother's age, the number of existing children, the age of the youngest child and the mother's family type. Furthermore, the fertility quotient is divided by the mother's province of residence as the fertility quotient of each province is scaled to measure the historical number of births in the province. Within a projection period, the overall number of births in each projection year is adapted to the number of births in DREAM's national population projection.

For each birth, a 0 year-old child is added to the mother's family. The child's gender is simulated by a constant proportion of newly born are considered boys and girls respectively. This proportion is calculated on the basis of historical data.

Due to the definitions of the origin groups, the origin group of the newly born depends on both the origin of the father and the mother. Based on the historical data, we construct a conditional transitional probability for the child's origin. We use the same transitional probability division as in DREAM's population projection, cf. Hansen and Stephensen (2012). From this division, we find the child's origin.

Figure 2.3 shows examples of the fertility quotient. For first-time mothers, the fertility depends on the mother's province of residence, age and family type. The fertility peaks for first-time mothers in the beginning of the 30s, cf. Figure 2.3a. Persons in couples have a remarkable higher fertility rate than single females. The female's family type is determined at the beginning of the year, and if a single gives birth during the following year, she has a significantly higher probability to become a part of a couple the following year compared to a single that does not give birth. For multiparas, the fertility quotient also depends on the number of child in the mother's family and the age of the youngest child. The fertility quotient is increasing until the youngest child becomes 2–3 years of age, where after it becomes decreasing, cf. Figure 2.3b.

Figure 2.3. Age related fertility quotient.



Sources: *Own calculations based on register data from Statistics Denmark.*

Note: *The probabilities are aggregated to only be divided by the age of the mother, number of children in the family, the age of the youngest child and marital status.*

2.3.2. Mortality

Deaths are simulated for mortality divided by age, gender, province of residence and family type. Mortality varies over time as prospectively we expect a continuation of the historical tendency of the lower mortality and thereof a following increase in average life expectancy.

When a death occurs, the person is removed from the population in that projection year. Our concept of mortality is based on the death probabilities in DREAM's population projection[32], where the age related mortality for each gender is projected using the Lee-Carter method. This method is based on extrapolation, whose basic assumption is that the future development can be

[32] The death probabilities from the population projection are divided further by family type, and for each province the number of deaths is scaled to the historical number.

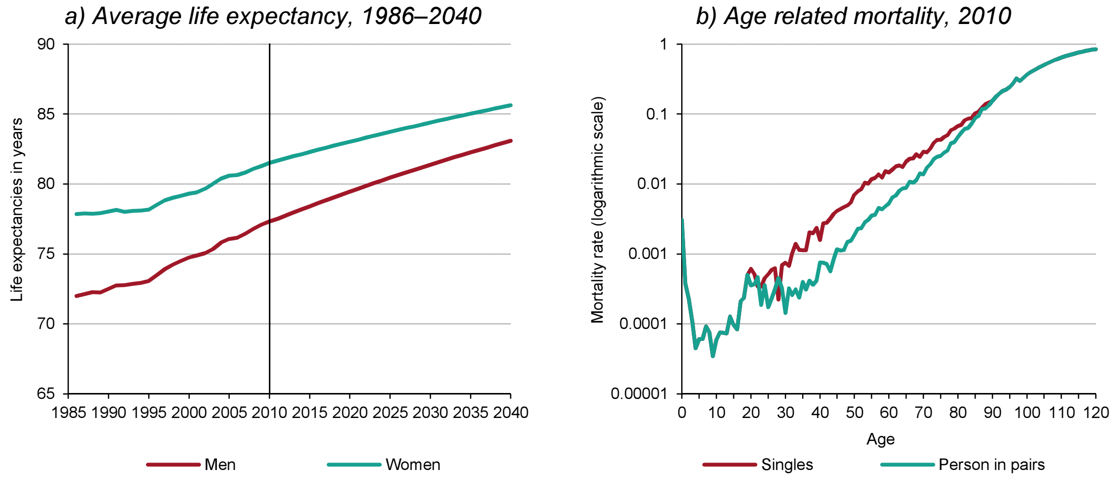
described from the historical development. So the method continues the tendency, which is observed historically, to lower mortality in all age steps up to about 100 years.

The development in the population's mortality pattern can be described by the development in the remaining life expectancy for the individual age steps. The remaining life expectancy for a given age step depends on mortality in all older ages. A 0-year-old's remaining life expectancy is often denoted as the average life expectancy and contains information about the mortality in all age steps. Therefore, the average life expectancy expresses the overall mortality in the projection year.

The result of the projection of the mortality probabilities is that the average life expectancy in the beginning of the projection increases at the same pace as in recent years. In the projection period, a gradual deceleration happens in this growth, cf. Figure 2.4a[33].

In the historical data, a significantly lower mortality rate is observed for persons in couples than single persons, cf. Figure 2.4b. Therefore, we include family type in the mortality probabilities in the projection. The division occur by scaling the mortality rate from DREAM's population projection for all of the projection period. The scale factor is determined from deaths in the 2008–2010-period divided by family type. Figure 2.4b shows the mortality rate in 2010. For children, there is no difference on mortality rate by family type. From the beginning of the 20s, a significantly lower mortality probability is observed for persons in couples than for single persons. The difference decreases with age.

Figure 2.4. Average life expectancy and age related mortality.



Sources: *DREAM's population projection of 2011 and own calculations based on register data from Statistics Denmark.*

Note: *The vertical line in the figure to the left indicates the shift between historical data and forecast. The probabilities in the figure to the right are aggregated be divided just by age and marital status.*

2.3.3. Immigration

In the projection, we consider the overall number of immigrants in each of the five origin groups[34] as being exogenous and given by the level in DREAM's national population projection. We

[33] See Hansen and Stephensen (2012) for further description of the expected development in mortality.

[34] The five origin groups are defined by a person's type of origin (immigrant, descendant, the rest) and country of origin (western, non-western). The five origin groups are: the rest of the population (i.e. persons not belonging to the four other groups), immigrants from non-western countries, immigrants from western countries, descendants from non-western countries and descendants from western countries.

distinguish between two types of immigration in the national population projection. For immigrants without Danish citizenship there is an exogenous influx while for all other there is a remigration, which is calculated from remigration frequencies. The future immigration is projected on the basis of historical data, international trends and knowledge of Danish rules on this specific area, cf. Hansen and Stephensen (2012).

DREAM's population projection gives an estimate of the overall number of immigrants in every projection year. In the microsimulation model, this number of immigrants is subtracted from a poll containing all immigrants within in period 2007–2009. In each origin group, we assume that the immigrants obtain the same demographic characteristics and family composition as in this period. Furthermore, the future immigration will distribute itself among the provinces as in the 3-year period.

For each immigrated family, we also register which type of dwelling the immigrants move into. In the projection, the immigrant families are assigned a dwelling with the same characteristics as observed in the actual immigration.

A part of the immigration occurs, involving already existing families. By the creation of the immigration pool, we observe which immigrant families who immigrate to an existing family. We also observe all characteristics for this family as the immigrant family is joining. If we draw an immigrant family who is joining an already existing family, we find a family with the same characteristics in the projected population[35]. Therefore, we assume that a constant part of the immigration occur for existing families for the whole duration of the projection period.

2.3.4. Emigration

Emigration is simulated by using emigration probabilities. We model three types of emigration: emigration of a whole family including any children, emigration of one adult in a couple and emigration of one child living at home. The probabilities are calculated on the basis of emigrations made in the period 2008–2010 and are assumed to be constant over time for given characteristics.

If a person emigrates, this person's is deleted in the projection year. Emigration of a family includes all family members, i.e. including children living at home. We distinguish between families consisting one single and one couple. For singles, the emigration occurs on the basis of emigration probabilities distributed by age, gender, origin and if there are children in the family or not. For persons in couples, gender is not a part of the probability. For couples age is calculated as the average age of the adults and origin of each of the two adults have impact on the emigration probability

Emigration of one adult in families made up by a couple is simulated in connection with break-up of couples. If a couple breaks up, we have a conditional probability for that the break up has occurred as a consequence of one part of the couple emigrates. This probability is distributed by age, gender, origin and if there are children in the family or not. If an adult in a couple emigrates, we assume the children stay with the mother. Emigration of children living at home is simulated in connection with a child living at home moves out of the parental home. In that case, we use a

[35] We find a family in the already projected population for the immigrant family; a family that fits exactly the same characteristics. The immigration occur according to historical data by age, gender, origin, highest completed education, province, family type and if there is children in the family or not.

conditional emigration probability distributed by age, gender, and origin to decide whether the child emigrates.

2.3.5. Change of Citizenship

The number of persons without Danish citizenship who in a given year change their own citizenship to a Danish citizenship is simulated with the probability for change of citizenship, distributed by age, gender and origin.

The transitional probability is the same as used in DREAM's population projection and is calculated for the period 2008–2010. The probability for a change of citizenship is defined as the proportion of persons in a given population group who become Danish citizens, cf. Hansen and Stephensen (2012). In the projection, the probability is assumed to be constant over time. The opposing movement from Danish to non-Danish citizenship is not modelled; as it is so low it in all fairness can be disregarded.

2.4. Socioeconomic Events

Socioeconomic events determine a person's choice of education and labour market affiliation. The projection models each person's route through the educational system. Every person is assumed to begin at elementary school, after which the transitional probabilities determine the further course. When a person leaves the educational system, he or she enters the labour force by a certain probability.

As a rule, every person is a part of the labour force. From this point, we can conduct different levels of retraction. For example, maternity leave usually causes a short absence from the labour force, while voluntary early retirement is of a more permanent character. For each level of retraction, there is a probability of returning to the labour force.

Table 2.7. List of transitional probabilities that determine socioeconomic events.

Event	Estimation model	Characteristics for probability
Initial division for 15-year-old	Observed	Gender, origin, highest completed education, present education and academic year of present education
Present elementary school	Projected	Age, gender and origin
Present non-elementary school	Observed	Gender, origin, highest completed education, present education and academic year of present education
Begin education	Projected	Age, gender, origin and highest completed education
Change labour market status	Observed	Age, gender, province and present labour market status

Source: *Own creation.*

Note: *With observed transitional probabilities we mean probability distributions, which are calculated directly from data (raw transitional probabilities). With projected probabilities we mean raw probabilities, where we draw a possible trend, which is projected for a number of years where after it deflects. This method is described in Rasmussen (2012).*

Table 2.7 shows a list of transitional probabilities that are used to project socioeconomic events. For two of the events, the probabilities calculated from data are combined with a method to clean any noise. From the noise-cleaned figures, we draw a possible trend, which is projected for a number of years where after it deflects. This method is described in detail in Rasmussen (2012). For the other three events, the transitional probabilities are calculated directly from data, called observed or raw transitional probabilities.

An example on a socioeconomic event is to consider a person who is undergoing an education, which is not elementary school. We will then have a probability for that this person continues his or her education the following year, completes the education or drops out without completing the education. Among other things, the probability depends on previously completed educations, the type of present education and academic year. The probability for not drop out will also be larger, if the person already has completed a relevant secondary education. In this way, the behaviour on a given education, apart from characteristics such as gender, age and origin, will also depend on completed education and academic year. The simulated education behaviour is independent of province of residence.

The modelling of the choice of education and affiliation to the labour market respectively is described below.

2.4.1. Choice of education

For each person, we simulate the choice of education by using transitional probabilities, which describes the progress through the educational system. The probabilities are calculated for the period 2008–2010 and are the same as used in DREAM's education projection, cf. Rasmussen (2012). The projection will continue the tendencies of recent years, where a relatively high share of the youth complete a higher education.

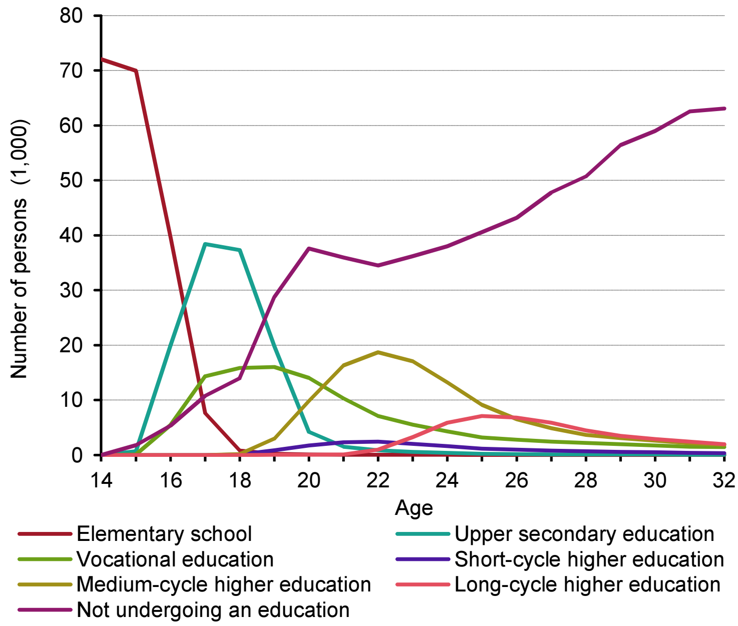
In addition to demographic characteristics, each person has an educational status that is updated as the person begins, complete or drop out of an education. The educational status is described by using three variables. *Highest completed education* is the highest ranking education and not necessarily the latest completed education. *Present education* indicates the education, where the person is accepted in that year. If the individual is not undergoing an education but for example is an active member of the labour market, then the present education is registered as not undergoing education. *Academic year of present education* indicates the number of years passed since the person began the education. This should not be confused with the number of completed normed academic years.

Figure 2.5 shows persons between 14 and 32 years distributed after present education. The figure shows a person's progress through the educational system[36]. As 14–15-year-old, most persons are undergoing an elementary education, which typically will be completed when they are 16–17-years-old. Immediately hereafter, most of them begin a upper secondary education. When this is complete, a part of this group leaves the educational system to join the labour force, either of a more permanent character if you have completed a vocational education or of a more temporarily character in the event of a break from studies. However, a part of this group continues directly on a medium-cycle higher education, for example a university bachelor. The medium-cycle higher educations are typically completed when the persons reach 22–25 years of age where after you

[36] This is only an illustration of a "life cycle" since the figure shows a cross-section.

either join the labour force or begin a long-cycle higher education. Long-cycle higher educations are usually completed sometimes during the middle of the 20s. As 30-year-olds, by far most of the group are out of the educational system. A smaller part continues on a research training as well as a part re-enters the educational system in connection with beginning a continuing education.

Figure 2.5. Age related number of students by present education, 2010.



Sources: Own calculations based on register data from Statistics Denmark.

Note: Persons without a present education is as not undergoing an education.

Choice of education is described with three groups of transitional probabilities. The first is the probabilities for beginning an education after elementary school. The next represents persons who are not part of the educational system and apply for admission to an education. The last is persons who are undergoing an education, which is different from elementary school.

Choice of education for a birth cohort is projected by assuming that all 14-years-old attend elementary school. By given age and origin, they are split up as 15-year-old on highest completed education, present education and academic year of present education after the distribution observed among 15-year-old in 2010. This results in a division of 15-year-old by demographic and education relevant characteristics. Then the transitional probabilities decide the person's future progress through the educational system.

The majority of the 15-year-old is going to elementary school. The probability decides by age, gender and origin if a person completes or continues for one more year. If elementary school is completed, the probability also decides if the person continues directly on a new education and which one. If the person completes elementary school and does not continue directly on another education, then that person is not undergoing an education but will with a certain probability enter the educational system again at a later point.

After the completion of elementary school, to groups are used to project choice of education as we distinguish between if a person is undergoing an education or not.

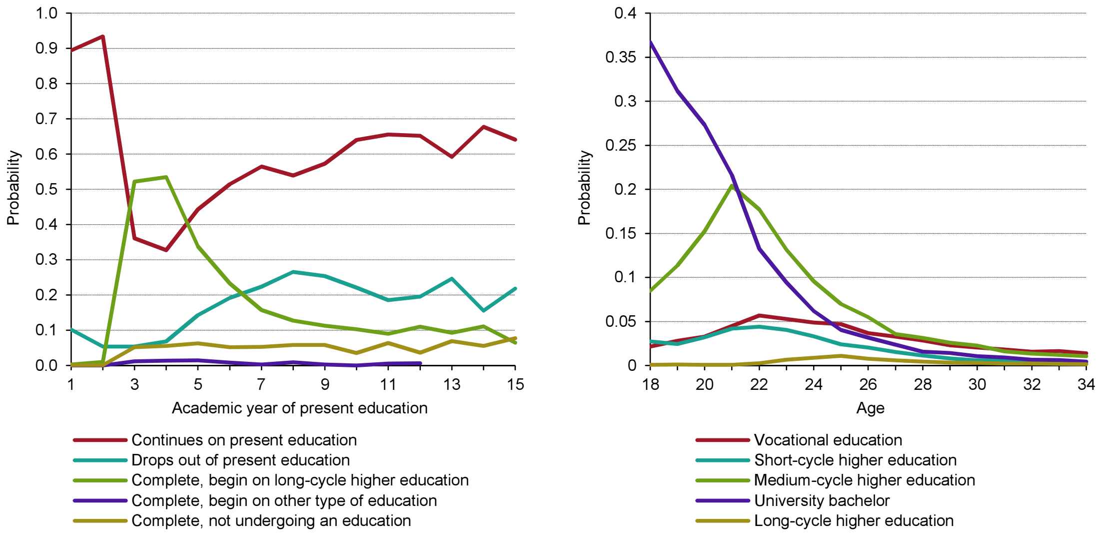
For persons undergoing an education, we have a probability distribution, which for a given gender and origin decides if the persons continue one more year at their on-going education, drop out of or complete that education. If they drop out of or complete the education, then the probabilities also decide whether they begin a new education immediately (and which one), or if they move outside the educational system (sabbatical year, work etc.). For persons who are not undergoing an education, we have transitional probabilities that decide if a person begins an education (and which one). They are distributed by age, gender, origin and highest completed education.

In the projection, the person's simulated educational status (meaning their on-going and highest completed education) is updated every year using the method described above. **Figure** 2.6 shows an example of the applied probabilities. The figure shows a person who has completed a general upper secondary education. We look at two conditions probable for that person.

Figure 2.6. Probability for person with general upper secondary education undergoing a bachelor degree (left) and outside the educational system (right).

a) Probability for continuing, dropping out of or completing for a person undergoing a bachelor degree

b) Probability for beginning an education for a person outside the educational system



Sources: Own calculations based on register data from Statistics Denmark.

Note: The probabilities are aggregated compared to those used in the projection model.

If a person with a general upper secondary education has begun a university bachelor, then we have a transitional probability in every academic year which determines whether that person continues, drops out of or completes the education, cf. Figure 2.6a. Is the person on first or second academic year, we have a 90–95 pct. probability to continue next year and 5–10 pct. probability to drop out. The probability to complete is largely equal to zero for the first and second academic year. After third or fourth academic year, 60 pct. of the remaining persons complete their education. After four academic years, the probability to complete is decreasing, while the probability for dropping out is increasing. After seven academic years, virtually everyone will be out of the system as under 1 pct. of those who begun the education still are attending it.

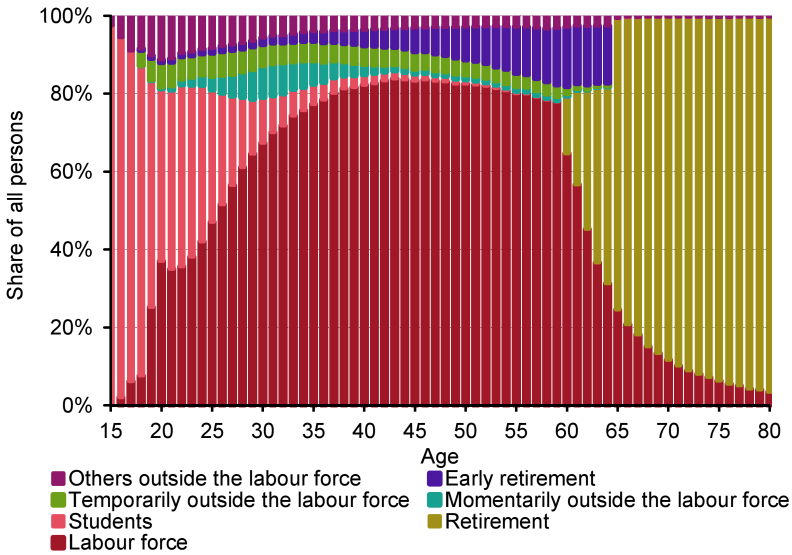
A person will typically complete a general secondary education as 19-year-old. If the person does not continue directly onto a new education, there will for each age step be a probability to begin a new education, cf. Figure 2.6b. At the youngest age steps, we have the highest probability for beginning a bachelor degree. This probability is decreasing as the age rises. From early in their 20s, our persons have the highest probability to begin a medium-cycle higher education.

2.4.2. Labour market affiliation

Person's labour market affiliation is simulated with transitional probabilities, which are distributed by gender, age, province of residence and present labour force affiliation. The transitional probabilities are calculated for the period 2000–2009. The relatively long timeframe when calculating these probabilities should be considered, as the transition between the different states of the labour market is dependent on cyclical conditions. By calculating the probabilities for several years, we increase the control of cyclical fluctuations in the behaviour.

Labour market affiliation is determined by seven status groups: in the labour force, students and five more labour market categories that express the level of retraction from the labour force, cf. Table 2.3. For example, persons on maternity leave will quickly return to the labour force, while a person on early retirement only has little probability to return.

Figure 2.7. Age related labour market affiliation, 2010.



Sources: Own calculation based on register data from Statistics Denmark.

Note: Labour market affiliation is shown as a share of the total population in each age step.

Figure 2.7 shows the population in 2010 distributed by age and affiliation to the labour market. The figure illustrates a person's labour market affiliation over a life span[37]. In the younger age steps, the majority are students. As a person completes his or her education, that person will typically join the labour force. The main part of who are shortly outside the labour force, are on maternity leave, which is why the share of people in this category is largest from age 25 to 40 years. Early retirement includes early retirement pension (*"førtidspension"*), which constitutes a rising proportion the higher the age. From the first possible voluntary retirement at age 60, the share of early retirees is constant until the first possible public pension age. Voluntary retirement through the early retirement scheme (*"efterløn"*) happens for a considerable share of the 60–64-year-old. With the possibility to obtain public age pension (*"folkepension"*) as 65-year-old, three

[37] This is only an illustration of a life cycle since the figure shows a cross-section.

out of four persons have retired from the labour market at this age step. Hereafter we have a continuous retirement for persons still in the labour force.

2.5. Household Specific Events

Household specific events determine the development in the number of households in the projection period. The development is determined from relatively few mechanisms. The number of household is increased, when a child living at home moves out, when an existing couple break up or by emigration. Opposite, the formation of couples, immigration of whole households and death of the single individual will reduce the number of households.

Death, emigration and immigration of whole families are considered as demographic events, cf. chapter 2.3. Household specific events are limited to children living at home moving out, the formation of couples and couples breaking up[38]. Emigration of single individuals from a household, i.e. one of the adults of a couple or a child living at home emigrates without the company of an adult, is considered as a couple breaking up or a child moving out of their parental home.

Table 2.8. List of transitional probabilities that determine household specific events.

Event	Estimation method	Probability characteristics
Child moving away from parental home to own family	Observed	Age, gender and province
- moving due to emigration	Observed	Age, gender and origin
- moving from home to join couple	Observed	Age, gender and province
Couple breaking up, form own family	Observed	Age, province, number of years in partnership, children and whether the couple gives birth the following year
- breaking up due to immigration	Observed	Age, gender, origin and children
- breaking up directly to new couple	Observed	Age and gender
Formation of couple from singles	Observed	Age, gender, province and if female gives birth the following year

Source: *Own creation.*

Note: *With observed transitional probabilities, we mean probability divisions calculated directly from data (raw transitional probabilities).*

Table 2.8 shows a list of transitional probabilities that projects the household specific events. All the probabilities are calculated directly from data. If a child living at home leaves his or her present family and does not die, this can result in three outcomes: The child moves to his or her own dwelling in Denmark (i) as single, (ii) together with a partner or (iii) emigrates to a foreign country. In the projection model, this is modelled by finding a probability, that a child living at home leaves his or her present family regardless the cause (although we leave out persons who die). If this probability indicates that the child living at home leaves his or her family, then we use a conditional probability (conditioned by that person moves away from home), which decides

[38] Change of dwelling is also a household specific event. The modelling of moving households is not covered in this chapter, but in chapter 3.

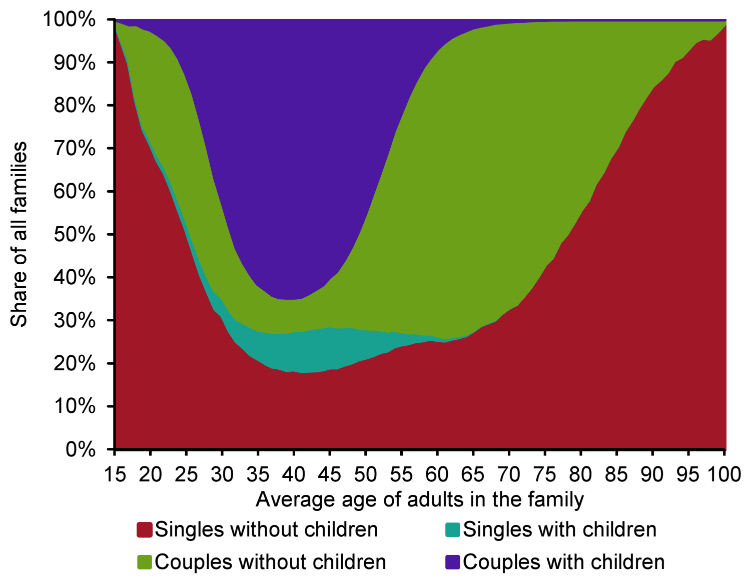
whether that person immigrates. If this is the case, that person is removed from the population. If it is not the case, that person moves away from home and establish a new family. A conditional probability (conditioned by that person moves away from home and does not emigrate) decides if that person moves directly in to a new family (couple) or if that person becomes single. In Table 2.8, we find these three probabilities belonging to moving away from home.

We use the same procedure for couples breaking up. First, a probability decides if an existing couple break up. If this is the case, another probability decides if one part of the couple emigrates. Then, another probability decides if the adults who have not emigrated surpass directly to a new family (couple) or if that person becomes single.

Couples breaking up are an example of a household specific event. For each couple in the population at the beginning of the year we have a probability for breaking up during the following year. The probability for a couple breaking up depends on the average age of the two adults, province of residence, duration of partnership in years, if the couple have children and whether the couple will have a child within the next year (birth is decided before couples breaking up). So an older couple will have a lower tendency to break up, just as couples who have just been formed have a larger probability for breaking up than couples who have been together for a long period of time.

Figure 2.8 shows the number of adults (excluding children living at home) in each age step distributed by family type and if there are children in the household or not. As very young, most young people not living at home make up a family, consisting only of themselves. The share of couples is increasing until the early 30s. Firstly, as more moves away from home, some moves happen as couples. Later as single people increasingly become a part of a new couple, like existing couples to lesser extent break up. From early in the 30s to the end of the 60s, the share of persons who live as a family is somewhat constant. Then the share is decreasing as one part of the couple dies. The families typically have children living at home, when the adults are between 25 and 65-years-old. A larger share of the couples has children than single persons.

Figure 2.8. Age related family type for persons not living at home, 2010.



Sources: Own calculations based on register data from Statistics Denmark.

Note: Family type is shown as a share of the total population in each age step.

Each of the following three sections describes the modelling of the three household specific events, which are included in the projection model and have significance for the number of households. The modeling of movements, which also is a household specific event but has no meaning for the number of households, is described in chapter 3.

2.5.1. Children and young people living a home moves out of their parental home

Based on a probability divided by age, gender and province, we simulate how many children and young people living at home moves out of their parental home in every projection year. The probability is calculated on the basis of movements from home in the period 2008–2010, assuming it is constant for the whole projection period.

There can be two causes for a child living at home leaving their present family. Either the child moves away from home and forms a family at their own or the child emigrates from Denmark. Given that a child living at home leaves their present family, it is simulated based on a probability distributed by age, gender and origin, if the child emigrates. If not, a new family is created for that child.

For all children moving away from their parental home (i.e. not emigrating), we simulate if that child become a part of a couple, using a probability distributed by gender, age and province. If that is the case, the child is added to the so-called matching pool, which contains all single persons who have a possibility of forming a couple within the duration of the projection year. If not, a family is created, which contain only that child.

In the projection, movements away from home are assumed to be permanent in the sense that children and young people living away from their parental home does not have the possibility to move back to their parents. By ignoring this, you will most likely overestimate the number of children and young people living away from their parental home (and thereby the number of families who are around 20-years-old). Therefore we model net movement from home in the projection, as the probability to move away from home in calculated from the number who move out of their home minus the number who move back into their old home. Hereby we achieve the correct family structure although we disregard the possibility of changing status from living away from home to living at home (i.e. the parental home). In the projection, children and young people who live at the same address as their parents are recognized living at home until they are 30-years-old. Statistics Denmark recognize children as living at home until they 25-year-old[39]. When you consider movements for children living at home and young people who move out of their parental home, it is inappropriate with an age limit of 25. For if one child living at home reaches the age of 25, he or she will technically move out of their parental home and create their own family, but still reside in the same dwelling as their parents. By setting the age limit for children living at home to 30 years, the extent of this problem is reduced significantly.

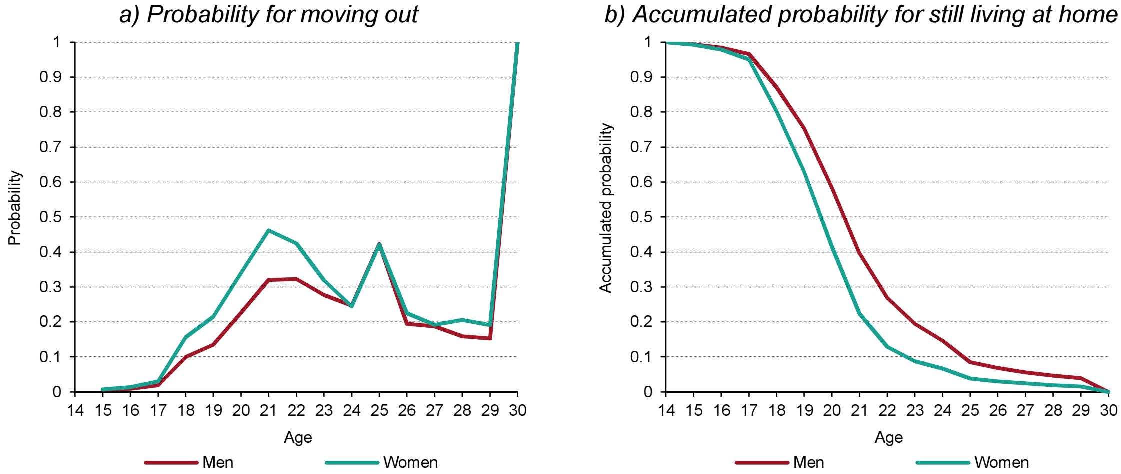
Figure 2.9a show the probability for children and young people living at home move out of their parental home. We assume they move out as 15-year-old at the earliest. There is a clear tendency that females move out earlier than males. The share of children living at home who

[39] In Statistics Denmark's definition of an E-family, children who live at the same address as at least one of their parents and are younger than 25 years old are recognized as living at home. In the projection, the age definition of children living at home is changed to be less than 30 years. The expansion of the age interval for children living at home is made, because a significant number of children are still living at the same address as one of their parents until they are more than 25-years-old.

move out peaks for both genders around age 21. Then the share drops up until age 30, where the probability rises the one, as children living at home move out the year they turn 30, by definition.

Even though the probability to move away from home peaks by age 21, it is under half who continue to live at home by this age. So it applies to 40 pct. of the boys and only 22 pct. of the girls cf. Figure 2.9b.

Figure 2.9. Probability for children living at home moving out of parental home.



Sources: *Own calculations based on register data from Statistics Denmark.*

Note: *The probability for moving away from home increased considerably by the age of 25. The reason is that the expansion of the age interval for children living at home is not completely identical with Statistics Denmark's definition of children living at home. The probabilities are aggregated only to be distributed by age and gender.*

2.5.2. The break-up of couples

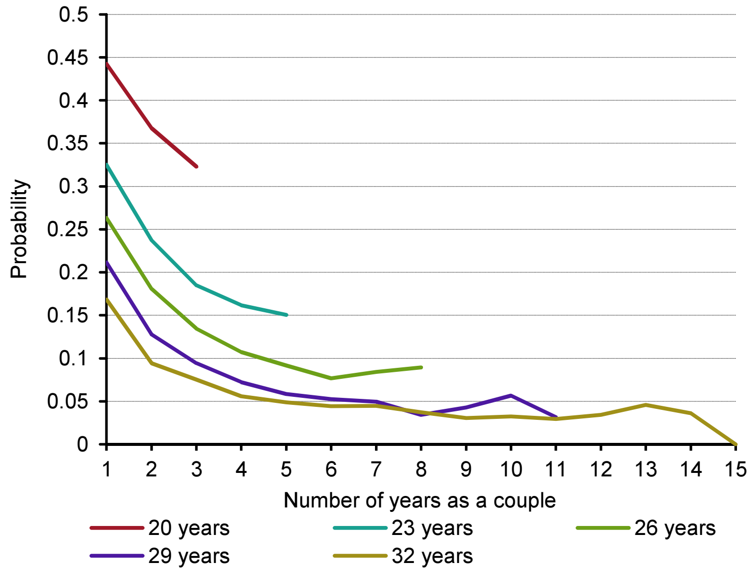
Existing couple have a risk of breaking up. This is simulated by letting all couple break up with a probability distributed by age, province of residence, number of years since the couple was formed, if there are children in the family or not and if the family gives birth to a child within the following year. The probability is calculated on the basis of couples breaking up in the period 2008–2010 and is assumed to be constant throughout the projection. By couples breaking up, it is assumed that any children in the family that break up follow their mother.

The break-up of couples can be caused by one of the adults emigrating. If a couple breaks up, then we have a conditional probability distributed by age, gender, origin and if the family have children. This probability decides whether one of the adult's emigrates. In that case, that particular person is deleted from the projected population. Only one adult in a couple can emigrate after a break up. If both adults emigrate, we consider it emigration of the whole family.

By the break-up of couples, each adult who does not immigrate has a possibility to form a new couple. The probability for this depends on gender, age and province. If an adult after a break up is to form a new couple, that person is added to the so-called matching pool, which contains all singles with the possibility of forming a couple during the projection year. Alternatively, we create a new family for the adult and children if any.

Figure 2.10 shows the probability that an existing couple break up for five selected age steps. The probability is conditioned by the adult's average age and number of years they have been a couple. The break-up of couples is most likely to occur at the youngest age steps and decreases gradually the older the age. For couples with an average age older than depicted in the figure, we see a slightly declining probability for breaking up, but the level does not differ significantly from the 32-year-olds in Figure 2.10. For all age steps, the probability for a break up is highest during the first year, after the couple has been formed. The probability stabilizes after approximately five years, though with a tendency to continuously be slightly declining. After ten years of partnership, the probability levels out completely.

Figure 2.10. Probability for the break-up of couples for select age steps.



Sources: Own calculations based on register data from Statistics Denmark.

Note: The probabilities are aggregated to only be distributed by age and number of years in partnership.

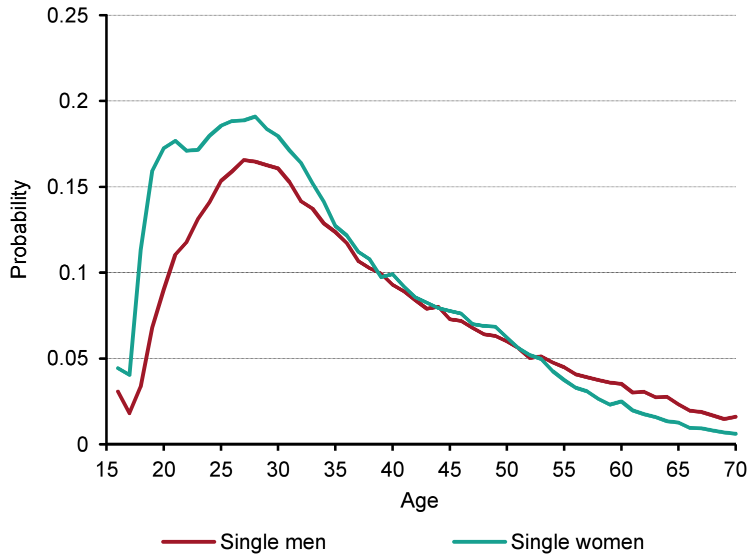
2.5.3. The formation of couples

The formation of couples is simulated for all singles with a probability that determines how likely it is that the person is added to the matching pool. All singles in the pool experiences the formation of a couple during the projection year, while all persons outside the pool remain single. The formation of couples occurs by pairing all persons in the pool by the end of each projection year. By the matching, we consider a set of characteristics (gender for example, so your typical couple will consist of a male and a female). The probabilities for the formation of couples are calculated for the period 2008–2010 and are assumed to be constant during the projection.

In the model, singles can join the matching pool in three ways: Firstly, all singles are exposed for the possibility of forming a couple. This is simulated using a probability distributed on gender, age, province and if the single female gives birth during the following year (in that case, we have a higher probability for the formation of a couple). If a single is included in the matching pool, the whole family is added to the pool including any children. Secondly, children and young people who move out of their parental home can be added to the matching pool to form a new couple with a probability distributed on age, gender and province. Thirdly, persons in couples who have just broken up and not immigrated have a possibility to be added to the matching pool. This happens with a probability distributed on age and gender.

Figure 2.11 shows the probability for singles forming a couple. The probability is increasing until the latter part of the 20s, where it decreases the older the age. As young, single females have a larger probability than males to form a couple, while the situation is reverse in the older age steps.

Figure 2.11. Probability for singles forms couples.



Sources: Own calculations based on register data from Statistics Denmark.

Note: The probabilities are aggregated to only be distributed on age and family type.

After simulating the break up and formation of couples, we have a pool of singles that will form a new couple during the projection year. The next step in the simulation consists of pairing all persons in this matching pool, while considering in which province the singles reside as well as their age, gender and highest completed education for the adults.

From the historical data, we have a distribution on how singles form couples across the above characteristics. For example, you will typically see that males form couples with females, that males are a couple of years older than their partner and that the probability for finding a partner is largest in the same and neighbouring provinces. When singles in the matching pool are paired, the distribution of singles that form couple is maintained to the greatest extent possible. This match the assumption that future singles given age, gender, province and highest completed education are inclined to find a partner similar to the one they will find today. The applied method of pairing singles from the matching pool is described in detail below and in Stephensen & Markeprand (2013).

In the model, the formation of couples also appears by the immigration of persons to an existing family. In the model, the number of immigrants is considered exogenously. The overall number of immigrants is drawn from a pool containing the last three years of immigration. At the same time, we observe which immigrant families that immigrate to an existing family. If we draw an immigrant family that is to be united with an existing family in the population, the immigrant family is matched according to historical data and the two families are then united.

2.5.4. SBAM

For the construction of the microsimulation model, we have developed a new method for pairing singles belonging to the matching pool. The method is called SBAM (Sparse Biproportionate Adjustment Matching) and have more advantages compared to previous models.

The formation of couples is often modelled by using either a *stable marriage approach* or a *stochastic approach*, cf. Parese (2002).

Using a stable marriage approach, one assumes that males and females have preferences for each other, and that these preferences can be estimated from data. A stable marriage structure is given by a situation where the couple structure cannot be changed without making someone worse off. This method is difficult to implement. Partly because an estimation of preferences is a difficult econometric exercise, and partly because the simulation model will run relatively slow as it is time consuming to implement an algorithm that satisfies the stability condition. The stable marriage method is used in the microsimulation models CORSIM and DYNACAN[40] among others, cf. Easther & Vink (2000) and Morrison (1999).

In the stochastic approach, it is assumed that the probability for a male and a female form a couple decreases with the degree of differences and couples are formed using a Monte Carlo method. In the model DYNASIM[41], the probability for the formation of couples for example is determined by differences in the persons' age and education, cf. Zedlewski (1990). This method is considerably easier to implement, both regarding estimation and algorithm complexity. The cost however is that the method gives a relatively coarse modelling of the formation of couples.

SBAM is designed to both give relatively detailed presentation of the pattern of formation of couples and at the same time a fast simulation. The method can be characterized as either a cross-entropy minimizing method or a matrix balancing method (defined below).

The SBAM method is based on historical observations of formation of couples from one or more years, distributed on different characteristics such as age, gender, education, geographical region etc. In a given projection year, we use a matching pool of persons. If the persons in the matching pool are distributed on types as in the historical data, the matching problem is easy to solve: Couples are distributes as in the historical data. If this is not the case (which it typically is not), the couples must be distributed in a new way. One principle could be to distribute the couples so that the distribution deviates as little as possible from the historical distribution. This can be interpreted as a so-called matrix balancing problem (Schneider & Zenios, 1990). Here the original data is adjusted (defined as a matrix) such that the row and column sums are given by predefined values.

A number of solutions exist to this kind of problem. One such solution is called biproportionate adjustment (or RAS adjustment). This method has at least two advantageous properties: It is relatively easy to implement, and it has a nice interpretation. Using biproportionate adjustment, the outcome can be interpreted as the result of a so-called cross-entropy minimization (McDougall, 1999). In other words, the SBAM changes the couples' composition in relation to the

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[40] CORSIM (Cornell Microsimulation Model) and DYNACAN are both dynamic microsimulation models that are developed and maintained at Cornell University, USA and the Canadian Government. Both models projects persons and their families from demographic events as for example birth, death, the formation of couples, the break-up of couples as well as immigration and emigration.

[41] DYNASIM (Dynamic Simulation of Income Model) was among the first microsimulation models to use the dynamic approach. The model was originally developed by Urban Institute in Washington DC, USA.

historical distribution, so that the information loss is as small as possible. A precise entropy based definition of information loss is defined by Shannon's Theory of Information (Shannon, 1948)[42].

In the general matching problem, we consider N persons who are to form a couple to be in the matching pool[43]. They are divided into T types:

$$N = \sum_{j=1}^{T} N_j \tag{2.3}$$

Each type is defined by age, gender, origin etc., whereby T typically is very high[44]. The goal is to find real numbers, x_{ij} $(i = 1, \dots, T, j = 1, \dots, T)$, so that:

$$\sum_{j=1}^{T} x_{ij} = N_i \qquad , i = 1, \dots, T, \tag{2.4}$$

and

$$x_{ij} = x_{ji} \qquad , i = 1, \dots, T, j = 1, \dots, T. \tag{2.5}$$

The formation of couples is defined by equation (2.4). The variable x_{ij} indicates the number of persons of type i who form a couple with a person of type j. But if a person of type i forms a couple with a person of type j, the reverse is also the case per definition. Therefore we have the symmetry condition in equation (2.5).

The SBAM method is implemented by an algorithm that uses the pattern for formation of couples in the data. Below we will explain this in detail.

Data

The pattern for the formation of couples is observed by data, containing all information for all new couples at the end of 2008. This is constructed by choosing all adults in couples by the end of the year, and who did not have the same partner at the beginning of the year. For each adult in the couple, we register a set of characteristics at the beginning of the year (age, gender, origin, highest completed education, number of children, age of youngest child, and province of residence). For the couple, we register a set of common characteristics at the end of the year (province of residence, dwelling, etc.).

Let x_{ij}^0 be the number of persons of type i that form a couple with a person of type j, according to historical data. Data are constructed so that the symmetric condition is achieved[45]. In the historical data, individuals are distributed on T types, so that:

$$N_i^0 = \sum_{j=1}^{T} x_{ji}^0 = \sum_{j=1}^{T} x_{ij}^0 \tag{2.6}$$

The total number of persons in the historical data is given by:

$$N_0 = \sum_{i=1}^{T} N_i^0 \tag{2.7}$$

---

[42] Shannon's Theory of Information describes the technical conditions under which information most effectively can be transferred, so that the received information is separated from the external noise.

[43] We assume N is an equal number.

[44] An example with two genders, 50 ages (15–64 years), five educational groups and eleven provinces gives that T = 2 · 50 · 5 · 11 = 5.500.

[45] Each couple causes $x_{ij}^0$to grow by one and $x_{ji}^0$to grow by one.

It is an advantage to describe the problem with matrix notation. The historical data x_{ij}^0 can be placed in a symmetrical $(T \times T)$-matrix, X^0. Define the vector:

$$\vec{N}^0 = (N_1^0, \dots, N_T^0).$$

According to equation (2.6) both row and column sums in X^0 shall be given by $\vec{N}^0$.

Biproportional adjustment

The purpose is to pair N persons distributed in types in relation to $\vec{N} = (N_1, \dots, N_T)$. We wish to find a $(T \times T)$-matrix X, so that row and column sums are given by $\vec{N}^0$. This is done by X deviating as little as possible from X^0. In other words, we will perform a matching (X) to retain as much of the original information as possible from the historical data (X^0). This can be interpreted as a classical matrix balancing problem: "*Given a rectangular matrix A, determine a matrix X that is close to A and satisfies a given set of linear restrictions on its entities*", cf. Schneider & Zenios (1990).

Fundamentally, there are two types of algorithms in the matrix balancing: Scaling algorithms and optimization algorithms. Scaling algorithms multiply the rows and columns of the original matrix by positive constants until the matrix is balanced. Optimization algorithms minimize a penalty function that measures the deviation of the new matrix from the original matrix. In the SBAM and thus in the microsimulation model, we use the scaling approach. According to the biproportionate adjustment model (also called RAS adjustment), the matrix balancing can be solved in the following way: Start with the original matrix X^0. Scale all the rows such that the row sums are correct. Then scale the columns so that the column sums are correct. Repeat until convergence towards a new stable matrix is established.

When using the optimization algorithms, it is obvious that the new matrix deviates as little as possible from the original matrix (that is part of the definition of the problem). This is less obvious when it comes to the scaling algorithm. However, we apply that the outcome of our scaling algorithm can be interpreted as the outcome of an optimization algorithm, because biproportionate adjustment is an entropy-theoretic model, cf. McDougall (1999). The new matrix can be characterized as the solution to a cross-entropy minimization model. Entropy should here be understood in an information theoretical context, cf. Shannon (1948). By using the biproportionate adjustment model, we are actually minimizing the loss of information when changing from the type distribution $\vec{N}^0$ to $\vec{N}$.

Sparse algorithm

As mentioned before, the number of types T can become very large. The $(T \times T)$ matrices can therefore have so large dimensions that problems arise having enough memory (RAM) in your computer to solve the problem. As the matrices also contains many zeros (there are many type-combinations that does not exist in practice), it is obvious to develop a "*sparse*" version of biproportionate adjustment, i.e. a scaling algorithm to make working with sparse matrices[46] possible.

[46] A sparse matrix is a matrix with a lot of zeroes. It can be compressed so only elements different from zero are stored in the computer's memory. So a sparse matrix takes up significantly less memory space than an ordinary matrix.

Such a method is developed in C#[47] and is based on so-called *linked lists*[48]. A $(T \times T)$-matrix can be represented as a *SBAMMatrix*. A *SBAMMatrix* is a C#-object, fundamentally containing $2T$ linked lists: T linked lists for the rows and T linked lists for the columns. Each element in a linked list consists of a pointer and a reference to the next element in the list. In this way, data is represented twice: Both as columns and rows. This implies that a *SBAMMatrix* takes up more memory, but at the same makes it possible to perform the biproportionale adjustment much faster.

Overall implementation

The overall algorithm for the formation of couples looks like this:

1. Create a matching pool of the persons who have to be paired.
2. Calculate the type distribution in the matching pool.
3. Start with a SBAMMatrix containing the historical population.
4. Perform a bipropotionate adjustment of this SBAMMatrix, so the row and column sums match the type distribution in the matching pool. This is called the new SBAMMatrix.
5. Form the new couples by randomly drawing persons from the matching pool according to the new SBAMMatrix.
6. Stop when you have couples enough.

In the microsimulation model, all persons have a probability to join the matching pool. These probabilities are uniformly increased by 20 pct. compared to the historical observed frequencies to ensure the matching pool will be 20 pct. too large. As we will explain below, this is an advantage.

After the biproportionate adjustment (stage 4 above), we have new couples distributed by type. To be able to randomly draw persons of certain types from the matching pool, the pool is divided by types. As mentioned, we have many types (T is large). This stage of the algorithm could therefore potentially cause memory issues. To solve this, we use to integrated C# objects: Dictionary and List. A Dictionary object can contain a sequence of any one object (in this case, a List object containing persons of a given type j) and an index (in this case type j). The clever thing about a Directionary object is that you can quickly look up a certain object by indicating the index j. If the person in the matching pool is of type j, he or she is registered so:

1. If there is no Dictionary object with index j, then create one and add an empty List object.
2. Add the person to the List object in the Dictionary object with index j.

When applied to all persons in the matching pool, each List object in the Dictionary object is randomized. The formation of couples is based on the new SBAMMatrix. It consists of a sequence of couples who are chosen one by one. If a couple is of type (i, j), the procedure is as follows:

1. Choose Directionary with index i. Save the first person in the List object as person 1. Remove this person from the List object.
2. Choose Directionary with index j. Save the first person in the List object as person 2. Remove this person from the List object.

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[47] C# is the programming language used for the microsimulation model. C# is designed to be a simple, modern, generally applicable, and object orientated programming language.

[48] A “linked list” is a data structure, consisting of a group of elements that together form a sequence. Each element consists of data and a reference (a link) to the next element in the sequence. The structure is memory saving and makes it easy to add and remove elements from a random position in the sequence.

3. Create a household consisting of Person1 and Person2 and their children.

If the matching pool only consisted of the persons who were to be matched based on the observed marriage frequencies, problems would occur at the end of the procedure for the formation of couples. The problem arises because the adjusted couples are *real* numbers while only *integer* couples can be formed. The problem is solved in purpose by making the matching pool too large. Experiments have shown that 20 pct. is quite adequate for the procedure to work. The correct number of couples is obtained by restricting the couples actually formed in the final step of the procedure. When the number of formed couples is large relative to the effective type-couplings are high this rounding is insignificant in its impact on the resulting distribution of couples.

3. Housing Demand

The housing demand is projected using a housing module that simulates the behaviour of persons and families on the housing market, based on the household structure. The housing behaviour is complex, among other things due to dwellings count as a good that differs from other consumer goods[49]. We are dealing with a heterogeneous good, as all dwelling to a certain degree are unique. Furthermore, dwellings are a permanent good, consisting of a structure whose lifespan can be prolonged by maintenance and improvements as well as a property of land with an indefinite lifespan. In addition, movements between dwellings are connected with substantial transaction costs, dependant on ownership. The mobility in owner-occupied housing is therefore lower than the private rental market, for example. In microsimulation models, the housing behaviour is often partition in two by the decision to move from one dwelling to another and the choice of new dwelling in itself, cf. Coulombel (2011). The dual partition is used in this housing module by estimating probabilities to transfer from one dwelling to another (i.e. movement probabilities) and by choosing a dwelling with the given characteristics rather than another dwelling (i.e. choice of dwelling probabilities). The probabilities are included exogenously in the microsimulation[50].

The data basis for the housing module will be treated in chapter 3.1. The data are register based and contain information on persons, families and dwellings. The chapter will also describe the housing stock in 2010 with the different housing characteristics that is used in the module. These will be defined along the way. In chapter 3.2, the method for estimating probabilities will be described and discussed. Finally will the movement and choice of dwelling probabilities be estimated in chapter 3.3 and 3.4 respectively. The probabilities are estimated based on the period 2000–2010.

3.1. The Data Basis

The housing module is based on a set of panel data that is constructed for the purpose by the DREAM group. The data are register based and obtained on an annual basis by Statistics Denmark via the Science Service Act (“*Forskerserviceordningen”*) that is a system where researchers can buy access to detailed individual data from a number of key records. This forecast is based on the populated dwellings in 2010.

3.1.1. Data

The data basis for information on dwelling is constituted by the Building and Housing Register (“*Bygnings- og boligregistret”, BBR*). The Register delivers information on properties, buildings, dwellings and business units and is compiled annually as a full census of all dwellings in Denmark as of January 1. They supplement with city sizes which are obtained by the Danish Geodata Agency (“*Kort- og Matrikelstyrelsen”*). The data is delimited to occupied dwellings, which constitutes roughly 2.56 million in 2010, cf. Kristensen (2011)[51]. The housing module is not

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[49] Dwellings can pose as both a consumer and investment good. As the housing module projects the housing demand by using the household structure, it is fair to consider dwellings as consumer goods. Each household demand one dwelling they wish to occupy. However, this does not exclude that households demand owner-occupied dwellings they can live in with in order to make a profit. In those cases, dwellings also count as an investment good.

[50] The housing demand is projected as a consequence of movement and choice of dwelling. Strictly speaking, you can argue that movements and choice of dwelling are consequence of the relation between demand and supply on the housing market, cf. Coulombel (2011).

[51] Dwellings are identified by addresses in the building and housing register (BBR) and defined as unique units from location (municipality code, street code, house number, house letter, floor number and side/door number). It applies that a dwelling is occupied if at least person has his or her home address assigned to the dwelling, i.e. is registered on the BBR address by the Civil Registration System (CPR). The

capable of projecting the demand for holiday homes and such that people will use as their dwelling no. 2, 3 etc. Such dwellings have no registered address with the Building and Housing Register and are for the period 2005–2010 not compiled as dwellings according to Statistics Denmark[52].

The data basis for information on persons and families is formed by running a set of registers. The population statistics (*"Befolkningsstatistikken"*) constitutes the primary source as a full census of the population residing in Denmark as of January 1. In addition, we use a statistic for the family and household conditions (*"Statistik for familie- og husstandsforhold"*), The Family Statistics (*"Familiestatistikken"*), the Population's Education Statistics (*"Befolkningens uddannelsesstatistik"*) as well as the Registered Labour Force Statistics (*"Registerbaserede arbejdsstyrkestatistik"*). The movement and choice of dwelling probabilities will be estimated on person and family level. In the demographic module, the population is projected on household level. A household occupy one dwelling per definition and often formed by one family. However, for a number of dwellings it applies that they are occupied of a household consisting of more families. In 2010, the Danish population consists of 2.83 million families who are distributed on approximately 2.56 million households[53]. The projection presupposes that a household's movement and choice of dwelling probability is independent of the number of families in the household.

3.1.2. The housing stock

The housing stock is characterised by the number of dwellings are increasing over time, while we have a shift towards dwellings characterized by certain conditions at the same time. This has been identified by Kristensen (2011) concerning occupied dwelling types, their category, location, size and age, all for the past decade.

The dwelling type is defined by owner-rental relationship with the use of five categories. On one side, we have owner-occupied housing[54], i.e. dwellings used by their owner. The rest are different kinds of rental dwellings, i.e. dwellings used by tenant. Social housing[55] is owned by a social housing organization, while cooperative housing is owned by a private cooperative[56]. Privately owned rented housing[57] have a diverse ownership, which can consist of private persons, business partnerships, companies (i.e. stock and private limited companies and other companies) as well

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full population of occupied dwellings is used. So we include dwellings, which can be described as non-independent (i.e. dwelling without a kitchen) and non-all-year houses (i.e. business units and holiday homes).

[52] Cf. Statistics Denmark's quality declaration for "The Housing Statement" cf. www.dst.dk ("*Boligopgørelsen (tidligere boligtællingen)*").

[53] According to www.statistikbanken.dk, "FAM44N" and "FAM55N". Household with more than one family are usually seen, when several students share a flat or in housing collectives. Households consisting of one family that live together with their grandparents are another example.

[54] Owner-occupied housing ("ejerboliger") consists of dwellings occupied by the owner himself.

[55] Social housing ("almene boliger") is constructed and run by social housing organizations. The term "social housing" is a collective designation for three different types of housing: social family dwellings, social dwellings for the elderly and social dwellings for the young. Social housing for the elderly may, however, also be constructed and run by the Danish municipalities or regions (these two types are categorized as publicly owned rented housing) and by independent organizations (categorized as privately owned rented housing).

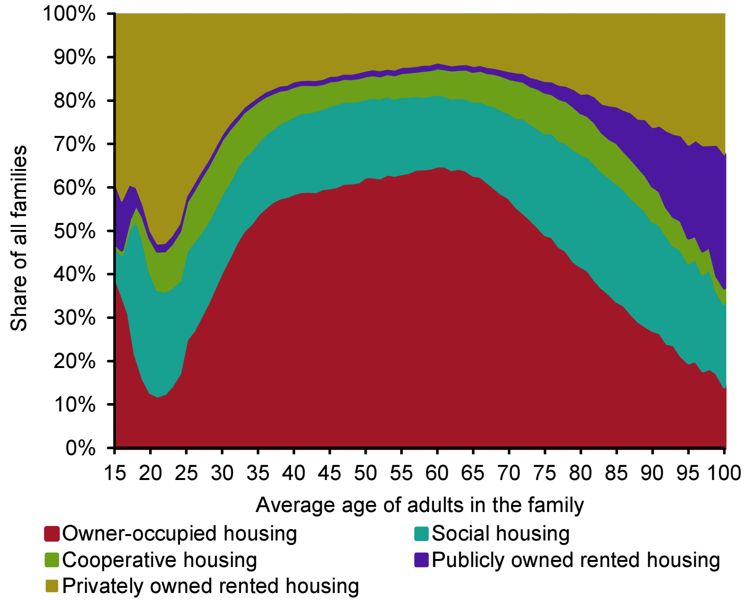
[56] Cooperative housing ("andelsboliger") consists of apartments or houses in a cooperative housing society. A member buys a share of the society thus causing occupancy of a dwelling in the association. Cooperative housing is to some degree similar to owner-occupied housing; however, pricing of cooperative housing is not free (as it is for owner-occupied housing). Cooperative housing is categorized as rented housing, considering they are owned by private cooperatives whose shareholders have the right of use of the dwellings. Cooperative housing is usually occupied of the shareholder but can also be occupied by a tenant.

[57] Privately owned rented housing ("private udlejningsboliger") consists of housing owned by private individuals, companies or independent institutions that are rented out. This includes e.g. dwellings in traditional rental properties and sublet owner-occupied housing.

as independent institutions (including associations and trusts). Publicly owned rented housing[58] is owned by the state, regions and mainly municipalities.

Owner-occupied housing makes up over half the populated housing stock (51.9 pct. in 2010). Social housing is the second most widespread housing type (approximately 20 pct.) followed by privately owned rented housing (approximately 19 pct.) The least widespread are cooperative housing (barely 8 pct.) and publicly owned rented housing (1.7 pct.). The period 2000–2010 shows that the share of owner-occupied housing is reduced by 1.5 pct. points. The development is however connected with some uncertainty. This is partly due to a larger number of dwellings of an unspecified type and partly that more owner-occupied housing is rented out on the private rental market. Rented owner-occupied housing is registered in data as privately owned rented housing and constitutes roughly 25 pct. of the private rental stock in 2010 against a share of 17 pct. in 2001, cf. Kristensen (2011). However, this has not resulted in the larger relative privately owned rental stock, as it has been stable around 18 pct.

Figure 3.1. Age related distribution of dwellings by type, 2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *For each age step, the figure shows the number of families that occupy a dwelling of a given type as a share of the total number of families in the age steps. Dwellings of unknown type have been left out of the figure.*

Figure 3.1 shows the distribution of dwellings on housing types conditioned by the average age of the adults in the household that occupy the dwelling. The age varies from 15 to 100 years. As young, a large share of those who have move out of their parental home live in a rented house. For the age groups at the beginning of their 20s close to 90 pct. of the total number of households live in rented housing. Of which share, the most of them live in a privately owned rented dwelling while there is also a relatively large share who live in social housing, due to rented housing is a relatively cheap housing type. That social housing form a relatively large share of dwellings with the young people, is related to a part of the social housing being actual youth and student housing. From the middle of the 20s to the end of the 30s, the share that lives

[58] Publicly owned rented housing ("offentlige udlejningsboliger") consists of housing owned by the municipalities, regions or the state that are rented out to individuals. These dwellings are typically targeted at certain groups of individuals, e.g. young people, disabled individuals or the elderly.

in owner-occupied housing is rapidly increasing. This happens as you typically find a steady partner and form a family. Then this share is fairly constant toward the present retirement age of 65 years. From the late 60s, owner-occupied housing constitutes a decreasing share, while an equal increasing share lives in rented housing, as people want a smaller dwelling (as their children have moved out) and a dwelling with less maintenance than the owner-occupied dwelling. The effect is also caused by people moving to retirement and senior housing, which typically are rented housing. The share that lives in publicly owned rented housing and privately owned rented housing increase relatively at the latter part of life as these housing types is constituted by retirement and senior housing to some degree. This also applies to social housing to a smaller extent.

The dwelling's category is defined according to their physical use. The dwellings are basically used for permanent habitation, business or leisure purposes[59]. The model is based on the populated housing stock and signifies that nearly all dwellings are registered as permanent housing.

More than 90 pct. of the populated housing stock consists of detached houses[60], terraced houses[61] and multi-dwelling houses[62]. Detached houses and multi-dwelling houses make up nearly 41 pct. and 38 pct. respectively, while 14.5 pct. is terraced houses. The remaining stock of dwellings for permanent residence consists of farmhouses[63], student housing[64], residential institutions[65] and "others". The residential institutions include retirement and senior homes as well as orphanages and juvenile homes. Homes not designed for permanent habitation is properties for commercial use[66] and holiday houses[67]. The distribution of dwellings by category has not changed considerably since 2000.

For households of 15–100 years, Figure 3.2 shows the distribution of the dwellings by category. As young, the main share of all household live in multi-dwelling housing. A relatively large share also lives in student colleges or student homes. From the middle of their 20s to the end of their 30s, the share of people living in multi-dwelling housing is heavily decreasing. A large proportion of the households moves into a detached house instead or to a lesser extend into a terraced house or farm house. This movement happens at the same time as you typically begin to form a

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[59] Housing category is determined by the usage of a dwelling or business unit (cf. the precise definition of housing category (*"boligart"*) at www.dst.dk). In the registration of permanent housing however, it is conditioned that they are used as "actual" habitation (dwelling with own kitchen), for a mix of business and habitation (unit with own kitchen) or as a single room (dwelling with a fixed cooking appliance, common kitchen or no kitchen). This does not apply to residential institutions that are used for common housing. Dwellings for business purposes are commercial housing and business units, but are considered as commercial housing. Dwellings for leisure purposes are designated as vacation housing and include holiday homes, allotment houses and gardens and other units for leisure purposes.

[60] A detached house ("parcelhus") is built independently from other houses and has its own garden. A detached house is intended for housing one family and typically has one or two floors.

[61] A terraced house, linked house or double house ("række-, kæde- eller dobbelthus") is a house in a property consisting of several independent housing units. Typically, such a property contains a row of identical or mirror-image houses that share side walls. Terraced houses are therefore characterized by a horizontal separation between housing units. There will typically be a smaller garden associated with each dwelling, and each unit is intended for housing one family.

[62] A multi-dwelling house ("etagebolig") is a dwelling in a property where multiple separate housing units are contained within one building. Each unit is intended for housing one family. A common form is a flat in an apartment building. A multi-dwelling house is characterized by a vertical separation between housing units. There can be multiple housing units on each floor and there are often multiple floors.

[63] A farmhouse ("stuehus til landbrugsejendom") is a general term for the main residential building of a farm. It is intended for housing one family and typically has one floor. It can either be connected to one or more barns to form a courtyard or be a separate building.

[64] A student house ("kollegiebolig") is a residential unit which is located in a dormitory. Student houses can be rented by young people in education or training. A student house is usually small single rooms, where approximately 10–20 students share a common kitchen (and on the older dormitories also shared bath). A student house is typically built to accommodate only one person, and the room will typically be located in a multi-dwelling house.

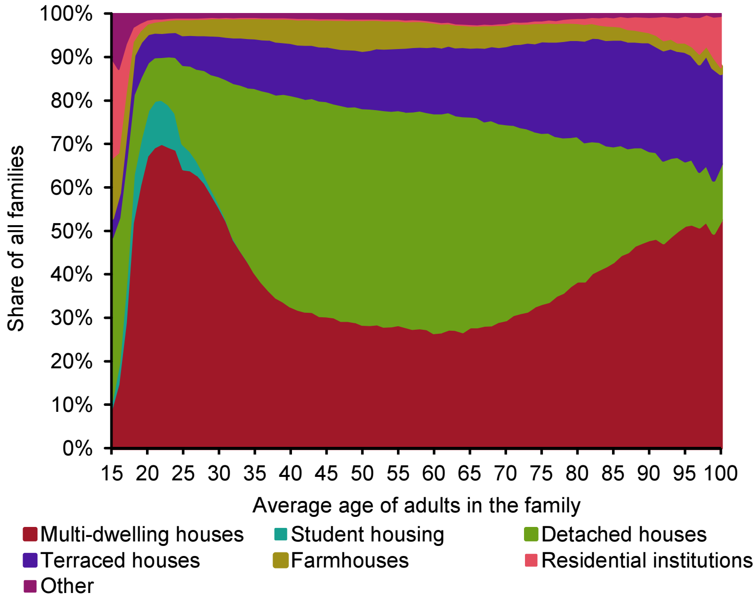
[65] A residential institution ("døgninstitution") is a home targeted at e.g. children or young people, weak or mentally ill people, or the elderly. In 2010, 19 percent of residents at residential institutions were 0–20 years old and 39 percent were older than the retirement age (65 years).

[66] Properties for commercial use ("erhvervsboliger") is properties where the primary use is specified as business purposes. This can for instance include properties with mixed commercial and residential use.

[67] A holiday house ("fritidshus") is a house built as a summer home that has been approved for permanent habitation.

family and want a larger dwelling with own outdoor areas. From the middle of their 60s, the share that lives in multi-dwelling and terraced houses is rapidly increasing. This happens as the households dispose of their detached houses and move into smaller dwellings, including retirement and senior homes. From the end of 70s age steps, residential institutions begin to form a substantial part of the housing stock, due to the majority of residential institutions are aimed at seniors.

Figure 3.2 Age related distribution of dwellings by category, 2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *For each age step, the figure shows the number of families that occupy a dwelling of a given category, as a share of the total number of families in the age step. Other categories include Properties for commercial use, holiday homes and other permanent housing. Dwellings of unknown category have been left out of the figure.*

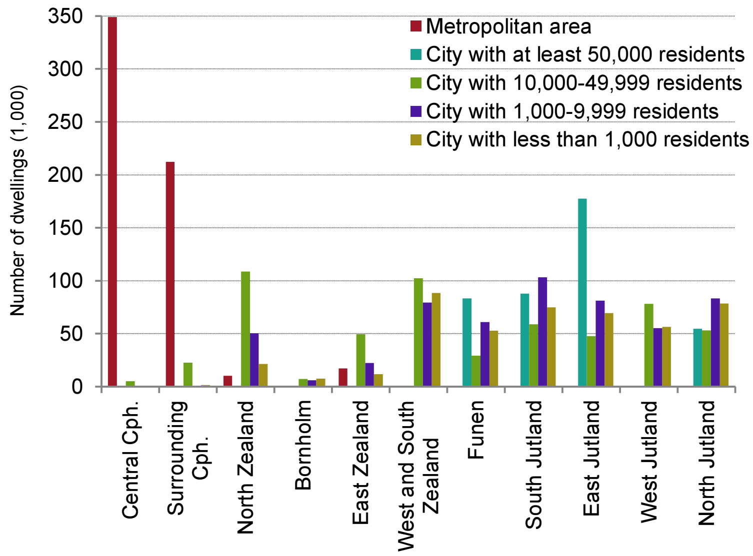
The location of a dwelling is expressed by provinces on a general level and subsequently with city sizes on a more local level. Figure 3.3 shows the distribution of populated dwellings in eleven provinces and five city sizes in 2010. The latter categorizes the size of the urban settlement in the area, which the dwelling is located in[68]. The categories include the metropolitan area and areas outside Copenhagen of at least 50,000 inhabitants, 10,000–49,000 inhabitants, 1,000–9,999 inhabitants and fewer than 1,000 inhabitants.

Measured by number of dwellings, then the Province of Central Copenhagen is the largest province east of Great Belt (*"Storebælt"*) and the second largest on a national scale. Nearly all the province's 355,000 dwellings are situated in the city of Copenhagen. A small number of dwellings are located in the municipalities of Dragør and Tårnby, which are less densely populated. The Province of Surrounding Copenhagen includes 237,000 dwellings, mostly located in the metropolitan area. From the figure it is also clear that the metropolitan area reach into both North and East Zealand. However, most of the dwellings in these provinces (approximately 191,000 in North Zealand and 101,000 in East Zealand) are situated in areas with 10,000–49,999 inhabitants. Bornholm is the smallest province with 20,500 dwellings. In West and South Zealand,

[68] As a main rule, an area of urban settlement is defined as a coherent settlement, where the distance between dwellings does not exceed 200 meters (www.kms.dk/Emner/Landkortogtopografi/Bypolygoner/).

approximately 270,000 dwellings are distributed evenly on areas with fewer than 50,000 inhabitants.

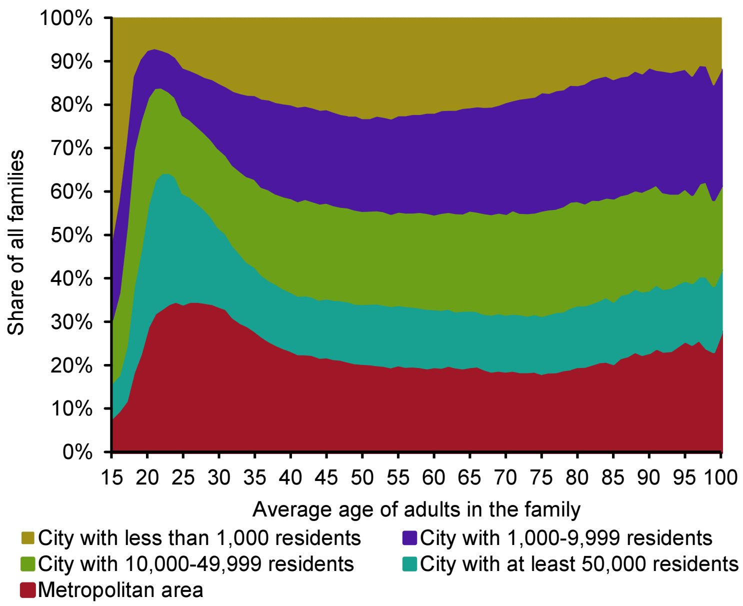
Figure 3.3. Distribution of dwellings by provinces and city sizes, 2010.



Source: *Own calculations based on register data from Statistics Denmark. Results have been created by a special run of tables 3.4 and 3.5 in Kristensen (2011).*

Note: *City size is determined by number of inhabitants. Areas with more than 49,999 inhabitants is situated outside the metropolitan area per definition.*

Figure 3.4. Age related distribution of dwellings by city size, 2010.



Source: *Own calculations based on register data from Statistics Denmark.*

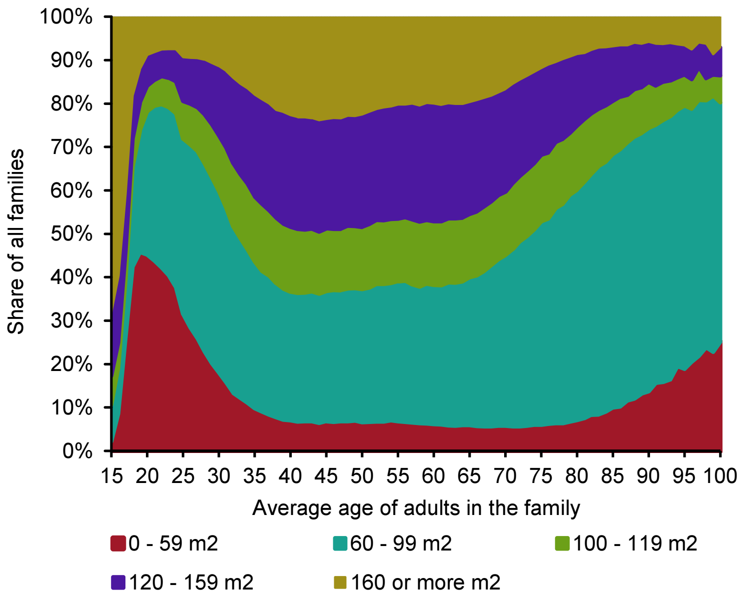
Note: *For each age step, the figure shows the number of families that occupy a dwelling in a given city size, as a share of the total number of families in the age step. Dwellings in unknown city sizes have been left out of the figure.*

With approximately 376,000 dwellings, East Jutland is the largest province nationwide. The majority of the dwellings are situated in cities of at least 50,000 inhabitants, because Aarhus is included. Funen and South Jutland comprise of approximately 226,000 and 325,000 dwellings respectively. The dwellings are distributed evenly on city sizes, although there are few dwellings in areas of 10,000–49,999 inhabitants. We see a similar situation for the approximately 270,000 dwellings in North Jutland. West Jutland comprise of 190,000 dwellings, which only are situated in areas with fewer than 50,000 inhabitants.

Figure 3.4 shows the distribution of dwelling by city sizes conditioned by the average age of the adults in the household. As a young person, you typically seek towards the metropolitan area and to other larger cities with a minimum of 50,000 inhabitants. This movement usually happens in connection with education, but also as young people to a larger extend have a preference for living in the larger urban areas. Towards the end of the 30s age step, a large part move away from the largest urban areas, while at the same time we see an influx to detached and terraced houses, cf. Figure 3.2. As the age steps rise, we see an influx towards the urban areas again, which is connected to the fact the at senior citizen wish to be close shopping possibilities and most retirement and senior homes are situated in the urban areas.

The dwelling areas in number of m2 express the size of the dwellings[69]. To be concrete, we define an interval variable for the dwellings overall gross floor area, i.e. the area in the building and housing register (BBR). Most dwellings have an area of 60 to 160 m^2. The living space generally becomes larger over time. This is seen by the share of dwellings of least 120 m^2 has risen gradually since 2000. At the same time, the share of dwellings less than 120 m^2 has been reduced.

Figure 3.5. Age related distribution of dwellings by size of dwelling, 2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *For each age step, the figure shows the number of families that occupy a dwelling of a given size, as a share of the overall number of families in the age step. Dwellings of unknown size have been left out of the figure.*

[69] The area consists of the overall gross floor area of a dwelling or a business unit, registered in the building and housing register BBR field 311, meaning areas for both habitation and other things than habitation, usually business purposes. Outer walls as well as parts of access areas and common living areas are also included (cf. the definition at www.bbr.dk).

Figure 3.5 shows the size of the dwelling distributed on the average age of the adults who occupy the dwelling. Young people usually lives in smaller dwellings of under 100 m^2, as they to a great extent live in apartments and student homes of that size. Furthermore, the young people will typically want a low housing cost, which is why they typically live in the smaller dwellings. The average dwelling size rises around when people turn 40, as the households move into detached and terraced house outside the larger urban areas. This can be seen especially in a rise of the larger dwelling of more than 120 m^2. When people get older a large share move back into multi-dwelling houses and the urban areas, which is why the average dwelling size is decreasing from in the middle of the 60s. At the latter part of life, a share moves into retirement and senior homes, which is why we see a relatively large increase in the share who lives in the smallest dwelling of less than 60 m^2.

The age of the dwellings is expressed by the time of use. In 2010, approximately 9 pct. of the populated housing stock has been in use from before the year 1900. Approximately 29 pct. have been put to use in the first half of the 20th century, while 57 pct. have been put to use in the second half of last century. The newest dwellings that have been put to use in the 21st century represents a still larger share as a consequence of the renewal of the housing stock. That share is approximately 4 pct. in 2010. The demolishment of dwellings also has to been seen as a cause that shifts in the distribution of dwellings by age happen over time. In addition, Kristensen (2011) points out that there is no significant signs of older dwelling are being demolished to a greater extent than newer dwelling. This is an effect of dwellings' life span being extended through renovation, rebuilding and extension of the existing structures.

3.1.3. Treatment of dwellings with unknown characteristics

In the historical data, we see dwellings with one or more unknown characteristics (dwelling type, category, size of dwelling, size of city). There are also a smaller number of households, where the dwelling cannot be identified. However in the first year of the projection, we have a province of residence for all households.

We do not want to include unknown characteristics in the projection. The initial housing stock is therefore cleansed for missing characteristics by distributing all unknown characteristics among the other values.

This is done by applying the statistical method Amelia in the statistics programme R, cf. Honaker, King and Blackwell (2013). The method replaces the missing observations with a probable known characteristic by using the remaining information in data, i.e. that the unknown characteristic is overwritten by a known characteristic according to the distribution observed in data. This happens by considering the remaining known characteristics for the household such as province, age, family type, number of children in the household, the highest completed education in the household and other known housing characteristics.

The initial housing stock is hereby cleansed for dwelling with unknown characteristics. In the projection, the used choice of dwelling probabilities is calculated, so no new dwellings with unknown characteristics can occur. If a movement to a dwelling with one or more unknown characteristics occur according to the historical data, then the observation is only used by calculating the movement probability (i.e. the decision if a movement occurs or not), while the observation is left out by calculating the choice of dwelling probability (i.e. the probability for choice of dwelling, given a movement occurs).

3.2. Data mining

A model based on individuals for the overall Danish housing market creates a need for method to analyse large quantities of data in an automated way. The purpose is to identify structures in the historical register data, which can explain the Danes' movements and choice of dwelling (cf. "revealed preferences"). Then the movement and choice of dwelling probabilities can be estimated as a basis for the simulation of movements and choice of dwelling.

Data mining is a term for statistical methods that automatically can identify structures in large data quantities and even project an individual behaviour, cf. Tan, Steinbach & Kumar (2006). The housing module uses a type of data mining, which consist of classifying the outcome of an individual's decision to move and if appropriate the choice of dwelling[70]. The classification is carried through using a decision tree that is implemented using the CTREE algorithm. Then the population of individuals is spilt into smaller and smaller groups, which results in "terminal groups".

3.2.1. Decision trees

Decision trees can be used to classify an outcome based on an individual's background characteristics. The outcomes are observed in data as discrete variables for individual's decision to move as well as their choice of dwelling. The classification models identify groups of individuals (i.e. terminal groups), where individuals are homogenous in relation to the outcome. Each terminal group must therefore contain individuals with roughly the same movement and housing behaviour, while the terminal group differ by being characterized by different behaviour. Within each terminal group, the transitional probabilities are calculated, i.e. probability to surpass from one dwelling to another (i.e. movement probabilities) and to choose a dwelling with given characteristics above another dwelling (i.e. choice of dwelling probabilities).

Trees are well suited for classification models in the projection of housing demand. They are non-parametric and necessitate therefore not any distribution assumptions. At the same time, they result in a fairly easily understood data analysis, where a population of individuals are partitioned in smaller and smaller groups based on background characteristics. It can be illustrated by considering person's decision to move to a new dwelling. Figure 3.6 shows a simplification, where family type, gender and age is used as the only characteristics. The tree partition the population into binary branches that group persons as couples, single males and females in a given age interval[71]. The tree ends with terminal groups wherein the movement probabilities are calculated.

The illustration expresses another advantage by decision trees. They can be constructed with both nominal, ordinal and interval variable. On the other hand, the disadvantages often concern the trees' accuracy in the projection of outcome, cf. Neville (1999). The decision trees are a simple way of expressing the data structures, which in reality perhaps are complex.

The tree in Figure 3.6 is simplified by just using family type, gender and age as characteristics. All terminal groups therefore contain relatively many persons. If the population contains persons in the age 18–99 years, we will have 246 combinations (82 ages times 3 combinations of family type and gender). The need to expand the tree by also characterizing persons with educational background (6 values), origin (5), labour market status (2), an indicator for if there are children in the household (2) and province (11) will appear later. Then we will have approximately 1.6 million

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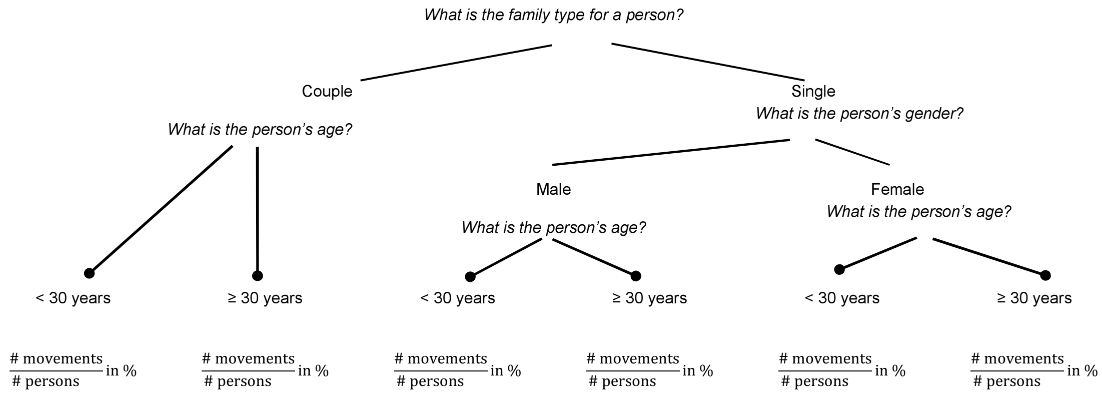
[70] Individuals can choose between a limited number of well-defined choices (cf. "discrete choice theory").

[71] The term decision trees are in this respect misleading, since branches don't express the individual's decision to do one or another. Splitting trees can therefore be more accurate, cf. Neville (1999).

combinations. The projection on a family level means that more variables characterize the two family members. If this applies to educational background (6 times 6), origin (5 times 5) and labour market status (2 times 2) for example, you will get 97.4 million combinations instead. Finally there will be a need to include dwelling characteristics in the tree. The result is a number of combinations that by far exceed the number of observations in the population. If you calculate the raw transitional probabilities, the data will be weak, because there is either very few or no observations in the many combinations.

Figure 3.6. Illustration of a decision tree for movement probabilities.



Source: Own creation.

The most important motivation behind the use of classification models consists of avoiding weak data. The models decides to join groups on the basis of different partitioning rules and such, so the transitional probabilities are calculated with a sufficient amount of observations in each terminal group. This is probably also the background for decision trees are used in a set of former microsimulation models used for housing market, cf. among others Clark, Deurloo and Dieleman (1990) for the American housing market and Fransson and Mäkilä (1994) for the Swedish housing market.

3.2.2. The classification model CTREE

A set of algorithms has been developed to construct decision trees using classification models. They generally differ by using different partitioning rules and have been developed for decades as computers have become more powerful[72]. Common for these are they seek the optimal partition, where the outcome variable's variation is minimized within terminal groups and maximized between terminal groups

CTREE ("conditional inference tree") is used in this housing module as one of the latest algorithms, cf. Hothorn, Hornik & Zeileis (2006). It is recognized by using a recursive binary partitioning of the population, where statistic test procedures are determining for if a group is partitioned or not. The total population is first partitioned into two groups based on an input variable and a limit value for this. The population for example can be partitioned by persons who are 30-years-old or older and persons who are younger than 30-years-old. The input variable and limit value creates the two groups that are "most" homogenous in relation to the outcome. This

[72] For a discussion on algorithms, we refer to Neville (1999) as well as Tan, Steinbach and Kumar (2006).

form of binary partition is then continued throughout all the groups, whereby the decision tree is formed.

The partition is based on the so-called partitioning rules that decide the homogeneity of the groups in relation to the outcome. They define the choice of test procedures among other things as well as terms concerning a minimum number of persons in the terminal groups.

Recursive partitioning

Methods for recursive partitioning was introduced with the AID algorithm ("automated interaction detection"), cf. Morgan & Sonquist (1964)[73]. In this case, the partition is determined based on the sum of squared standard deviations. AID was later developed further with the CHAID-algorithm ("chi-square automated interaction detection"), which is based on statistic test, cf. Kass (1980). The relation between the outcome variable and input variable for background characteristics are examined with a χ^2 test for independence. The input variable with the closest relation is used in the partition.

A known problem with recursive partitioning is *over-fitting*. Decision trees can be capable of predicting nearly all observed outcomes, if all variations in data are included through input variables, i.e. if the trees are too large. The problem arises if the tree becomes "over precise" in relation to be able to predict future outcome, if the same variations cannot be seen in the future. At the same time as the tree must not become too large, it is relevant to balance the consideration for they must be capable for describing details in the data, i.e. the trees cannot become too small either. In practice, we use two alternative methods to avoid "over-fitting", cf. Neville (1999). The term *stopping* implies that the recursive partitioning is stopped, when different criteria is met. This can require a minimum number of persons in each terminal groups and a maximum number of partitions. Often we test possible partitions against each other as in CHAID. The partition is stopped when no partition is significant. *Pruning* is an alternative that at first run constructs a decision tree that is "too large". Subsequently, the tree is pruned to the right size by comparing all possible prunings. "Pruning" is often used giving reasons for that criteria for evaluating possible pruning to a larger extent relates to the final tree than the case is for criteria by "stopping".

Another problem is concerning the trees' tendency to use input variables with many values for partitioning. This is known as selection bias toward variables with many possible partitionings. Additionally, the input variables with unknown observations pose a problem. In this model, persons with unknown characteristics will therefore be left out of the estimations.

CTREE

The CTREE algorithm implement binary partitioning in two steps. In the first step, the input variable is chosen at a given partitioning. In the second step, the partitioning is determined by the chosen variable. This is repeated recursively until the decision tree is formed. The stepwise implementation means that problems with selection bias towards certain input variables is avoided, cf. Hothorn, Hornik & Zeileis (2006).

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[73] You can find a comprehensive discussion on recursive partitioning in Neville (1999) and Strobl, Malley & Tutz (2009) among others.

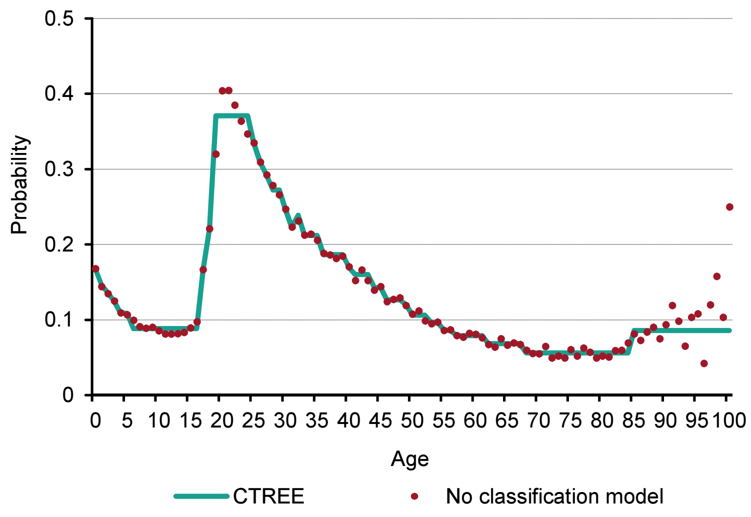
In step 1, the relation between the outcome variable and input variable is tested for independence. The input variable with the closest relation is chosen provided that the hypothesis of independence can be rejected by a specified significance level. The partitioning is stopped if this is not the case. So CTREE is based on “stopping” to avoid problems with “over-fitting”.

Independence test are performed as permutation tests and based on a conditioned distribution for the outcome variable given the input variable. The relation between the outcome variable and different input variables is expressed by a test statistics that is compared with a probability distribution dependent on the choice of test procedure. The input variable with the lowest p-value from the test statistics is chosen, given it is lower than 0.05[74].

Step 2 compares possible partitions for the chosen input variable. Which partitions are taken into considerations depends among other things on specified demand for a minimum number of persons in each terminal group (20) and significance level (0.05). The choice of partition is again based on permutation tests.

The housing module’s movement and choice of dwelling probabilities are estimated in the program R version 2.15.0. The CTREE algorithm is implemented in the “party kit” package that is a tool for recursive partition. A set of test with different algorithms has shown that CTREE is capable of predicting outcome to a greater extent than other applications. The use of CTREE is also validated by partitioning individuals in training and test data. Training data can contain half the randomly chosen individuals, for example. CTREE is constructed for this part and can be used to predict the individual’s outcome in test data. By comparing actual and predicted outcome in test data, we achieve an image of how CTREE is capable of explaining the behaviour of individuals.

Figure 3.7. Illustration of estimated movement probabilities for singles males, 2010.



Source: Own calculations with data from Statistics Denmark.

Note: Immigrated and emigrated person are not included. The probabilities are based on training data that contains half the population (randomly chosen).

[74] The selection is based on a set of independence tests. The p-values in step 1 are therefore Bonferroni-corrected, i.e. divided by the number of tests.

The use of CTREE can be illustrated by the decision tree in Figure 3.6. The algorithm decides an aggregation of individuals by age groups, whereby the number of terminal groups is reduced in relation to a situation without any form of aggregation. Figure 3.7 shows the movement probabilities that are estimated by a CTREE without a classification model respectively. The age profile for single males is shown as an example. We see several large fluctuations in the profile, when the probability is calculated without a classification model. CTREE results in a smoothed yet step-shaped profile. For example, groups with a relatively large age interval are formed around the 5–15-year-old and 70–85-year-old. The difference between the profiles will become more explicit, when we consider more background characteristics.

3.3. Movements

The movements on the Danish housing market are characterized by partly following a pattern over the life course and partly depend on cyclical trends. The housing module is therefore built by movement probabilities that are estimated for the period 2000–2010, based on information about person's age, gender, family relations, education, origin, labour market status and conditions of moving out of their dwelling[75].

3.3.1. The Danish housing market

Movements are characterized by a pattern over the life course. This is seen both internationally, cf. Coulombel (2011), and in Denmark, cf. Kristensen (2011). The first movements happen as a child or young person with their parents. At one point, the young people move out of their parental home and form their own families. Young people usually do not find their preferred dwelling at first try and in general move around a lot due to education and work, family and household relations, economic flexibility and so on. The movement frequency is largest at the beginning of their 20s and thereinafter decreasing by age, cf. Figure 3.7; due to the persons settle in their preferred dwelling and become more established with fewer work and household changes.

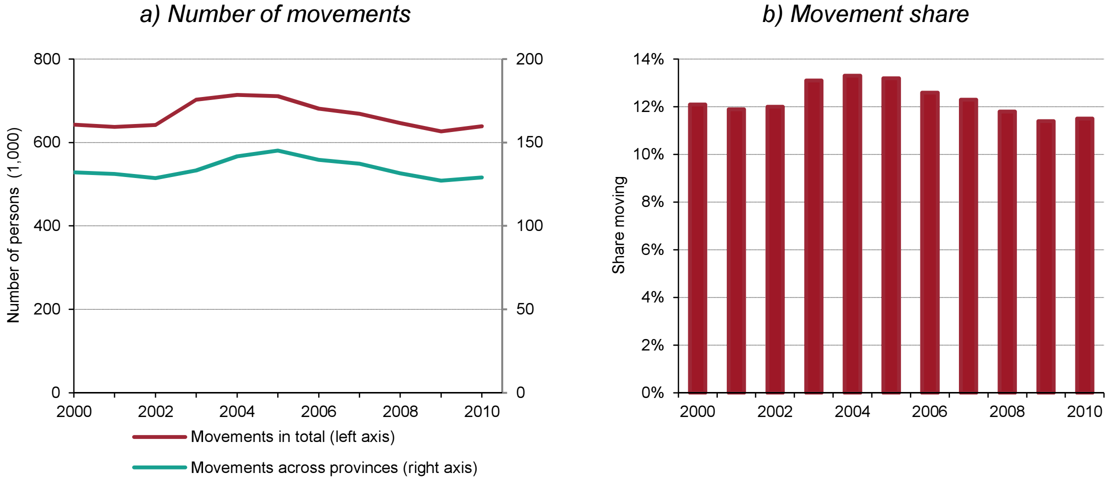
The movements are also affected by household specific events. The formation of couples means that a new family is formed either at one of the persons' existing dwelling or in another dwelling[76]. The event implies that at least one of the persons in the couple move to a new dwelling. The break-up of couples will also mean that at least one person moves, because the partners split up into each of their own family in the different dwellings. Young people living at home who choose to form their own family will also move to another dwelling than their parents.

The scope of movements on the Danish housing market generally varies along the cyclical trends, cf. Figure 3.8. During the 2000–2010 period between 625,000 and 725,000 move to a new dwelling annually. During 2000–2002, the scope is stabile around 640,000, while it rises significantly the following years to more than 700,000 in the period 2003–2005. Then the scope drops onward to 2009 to its lowest point in the decade. In 2010, it is back on the level of 2000–2002. The figure shows that movements across provinces represent about a fifth of the total number. It varies between 127,000 and 145,000 but develops relatively stable.

[75] The probabilities are estimated on the basis of an eleven-year period. This relatively long period is used to level out cyclical effects. For comparison, Statistics Denmark use a four-year period in their regional population projection, cf. quality declaration for "Regional population projections" (www.dst.dk).

[76] The model implies that the persons (adults and children living away from their parental home) in a couple live at the same address; due to the data that does not make couple living on different addresses possible.

Figure 3.8. Number of movements and movement shares, 2000–2010.



Source: Own calculations based on register data from Statistics Denmark. Results are gathered from table 4.1 and 4.2 in Kristensen (2011).

The movement share of the housing market shows a similar development and annually lie around 11–13 pct. However, we see significant variations for some groups of persons. Kristensen (2011) identify these movements by looking at connections between age, geographic location, education and work as well as family relations. Young people under the age of 30 have a movement share of 19–21 pct., while it is 7–9 pct. for adults from 30-years-old and above. Young people seek towards Central and Surrounding Copenhagen and East Jutland from where adults on the other hand seek away from the large urban areas.

3.3.2. Strategy for estimation

Movements are expressed in the model by probabilities to move dwelling. A move between dwellings is defined as an event that occurs by the end of the year by the latest. If a person's residential address at the beginning of year $t+1$ is different from the address by the beginning of year t, that person can be said to have move in year t[77]. This means that persons who move more than once during a year is just registered with only one move that year[78].

The housing demand is projected on family level, but movement probabilities are estimated on person level, depending on whether a household specific event occurs. Table 3.1 illustrates how probabilities are estimated for different parts of the population. The table indicates also movement shares in order to express how many that move to a new dwelling during a year in each part of the population. A family are characterized as single or couples, if they consist of one or two persons respectively. These persons can be adult (person over 29-years-old) or young people living away from home[79]. Families can also consist of young people living at home who stand before the choice of moving out and form a new family as either single or in a couple.

[77] Provided that the person has a known residential address in year t and $t+1$. If there are no registered information on both municipality number and address code in $t+1$, that person is registered with an unknown movement. This is primarily the case for persons who emigrated or die within year t.

[78] So short-lived movements are not registered in case that a person has the same residential address at the beginning of both year t and year $t+1$.

[79] Adults are all persons above 30-years.old, while young people are everyone between ages 0–29. This division is appropriate, because young people's probability to move away from home has to be estimated. Young people between ages 0–29 are living away from home, if they are residing at a different address than their parents. We assume everyone has move out of their parental home by the age of 30.

Table 3.1. Number of persons in population and movement share, 2000–2010.

	Person experience:		Population:	Number of persons:		Movement share:
	Brake-up	*Formation*		*2000–2010*	*Avr. per year*	*2000–2010*
Adults	No	No	Part 1[1]	10,095,909	917,810	8.3 pct.
	Yes	No	Part 2	924,932	84,085	62.2 pct.
	Yes	Yes	Part 3	109,880	9,989	77.7 pct.
	No	Yes	Part 4	1,046,790	95,163	61.5 pct.
Living at home	-	No	Part 5[2]	182,848	60,949	100.0 pct.
	-	Yes	Part 6[3]	206,034	18,730	96.2 pct.
Others	-	-	Part 7[4]	391,110	35,556	23.8 pct.

Source: *Own calculations based on register data from Statistics Denmark.*

Note: *The population only includes persons where all dwelling characteristics are known for the dwelling they move away from.*

Note 1: *The persons in part 1 are drawn from a simple random sample without replacement (20 pct.).*

Note 2: *The probability in part 5 is calculated based on the period 2008–2010. The movement share indicates the share of young people living at home that move away.*

Note 3: *The movement share is not 100 pct. due to the possibility of unknown information on a new address.*

Note 4: *Other consists of young people that cannot be characterized as living at or away from home due to unknown address. They are not included in the housing module.*

The movement probabilities are estimated in several stages. Firstly, they are estimated for persons who neither experience the formation or break-up of couple (called part 1)[80]. They include the majority of the population and have a relatively low movement frequency; cf. Table 3.1 is the movement share of approximately 8 pct. for 2000–2010. Secondly, the movement probabilities for persons who experience the break-up of couple are estimated (part 2 and 3). This applies annually for 91,000–95,000 persons[81]. The table shows that the movement frequency is higher if they form a new couple at the same time (almost 78 pct.) than if they become single (approximately 62 pct.). The projection assume that persons move dwelling if they are single and form a couple (part 4 and 6)[82,83]. Thirdly, the probability for move away from home for young people who does not experience the formation of couples is estimated[84].

Movement probability

The individual based simulation model is based on movement probabilities for person i. Events in the form of a movement are observed in the data as a binary variable ($movement_i$). At the same time, household and dwelling characteristics are observed for that person both before and after a potential movement during year t ($\boldsymbol{x}_{i,t}$ and $\boldsymbol{x}_{i,t+1}$ respectively).

[80] Probabilities for persons who neither experience the formation or break-up of couples (part 1) are in practice estimated on family level.

[81] Provided that the break-up is not caused by the emigration or death of one of the persons in the couple.

[82] We assume that the formation of couples is not coinciding with a person immigrating.

[83] In the simulation, it is assumed that all singles that experiences the formation of couples move to a new dwelling. According to Table 3.1, this is the case for nearly all young people living at home (approximately 97 pct.) opposed to adults and young people living away from home (60 pct.). The persons are given choice of dwelling probabilities where they have the choice of a dwelling identical to the one they moved out of.

[84] A simulation technical detail concerning young people living at home. They are given a probability to move away from home without forming a couple. Immediately hereafter, they are given a probability for forming a couple, conditioned by they are moving away from home. They are therefore divided into part 5 and 6.

Household and dwelling characteristics are used in the construction of a decision tree, where N persons in a part of the population are divided into P terminal groups. In each terminal group p, the movement probability is calculated as a transitional probability that is conditioned by the person's background characteristics before a potential movement:

$$Pr_p\left(movement_{i,t} = 1 \mid \boldsymbol{x}_{i,t}\right) \ = 1, \dots, P \qquad\qquad ,i = 1, \dots, N, \ \ p \tag{3.1}$$

Therefore, the movement probability is constant within terminal group p, as the decision tree assess that the persons in the group are homogenous in relation to the decision to move between dwellings:

$$Pr_p\left(movement_{i,t} = 1 \middle| \boldsymbol{x}_{i,t}\right) = Pr_p\left(movement_{j,t} = 1 \middle| \boldsymbol{x}_{j,t}\right)$$
$$,i,j = 1, \dots, N, \ \ i \neq j, \ \ p = 1, \dots, P \tag{3.2}$$

Families without events in the family structure

Movement probabilities for persons that neither experience the formation or break up of couples (part 1 of population) is estimated with a CTREE, which is specified by background characteristics for the household as well as the dwelling that is moved away from. Household characteristics are expressed with input variables for:

- Age
- Family type and gender
- Educational background
- Origin
- Labour market status
- Children in the household

The variables are defined in Table A.1 in appendix A3.4, where we distinguish between person and family level[85]. In addition, it also appears in the table if the variables are ordered or non-ordered with the consequence of which groups can be merged with a CTREE. Ordered variables limits the possibilities for merging groups, as CTREE only will be able to merge two group that appear next to each other. Age is a ordered input variable, where it is possible to merge two groups, consisting of 30-year-old and 31-year-old respectively. However, a merge of 30-year-old and 60-year-old is not possible[86]. The variable combing family type and gender is non-ordered, which makes it possible to merge groups of all combinations of its values, meaning groups can be merged for couples and single males, couples and single females or single males and females. In other words, non-ordered variables will not limit the possibilities for merging. In Table A.2 in appendix A3.4, the input variables for housing characteristics are defined. For the dwelling moved away from, they are expressed by:

- Province of residence
- Dwelling type
- Dwelling category
- Dwelling size
- City size
- Dwelling age

[85] On family level, several variables are defined in order to reduce the value set. This is done by expressing a family's characteristics with more than one variable.

[86] Unless all ages between 30 and 60 years are merged beforehand.

The break-up of couples

Couples consist of two persons that by a break up will divide themselves on two different dwellings. Movement probabilities are allocated to each person that experience a break up of couples in the population's part 2 and 3. They are estimated through CTREE with input variables for the same characteristics used in part 1.

The movement probabilities are estimated by two stages for partitioned couples. On one hand, we have the probabilities where both persons move to another dwelling. Then we have the probability for one person moving to a new dwelling, while the other stays.

Children and young people living at home

The probability for children and young people living at home in part 5 move out is estimated from raw transitional probabilities as described in section 2.5.1. We use input variables for age, gender, and province of residence.

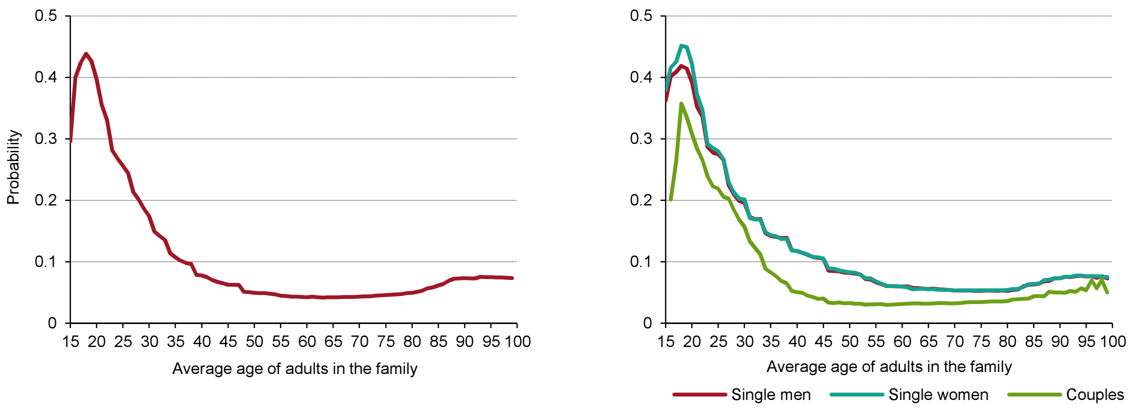
The movement probability is limited to age 15–29 years and based on a net consideration, thereby reducing the number and young people that move away from home with the number of young people moving back to their parental home.

3.3.3. Movement probabilities

The movement probability is generally decreasing the higher the age, when we consider persons in the age between 18–65 years. This applies for adults and young people living away from home that does not experience the formation or break up of couples, cf. Figure 3.9[87].

Figure 3.9. Estimated movement probabilities (part 1), 2000–2010.

a) The total population *b) Divided by family type*



Source: Own calculations based on register data from Statistics Denmark.

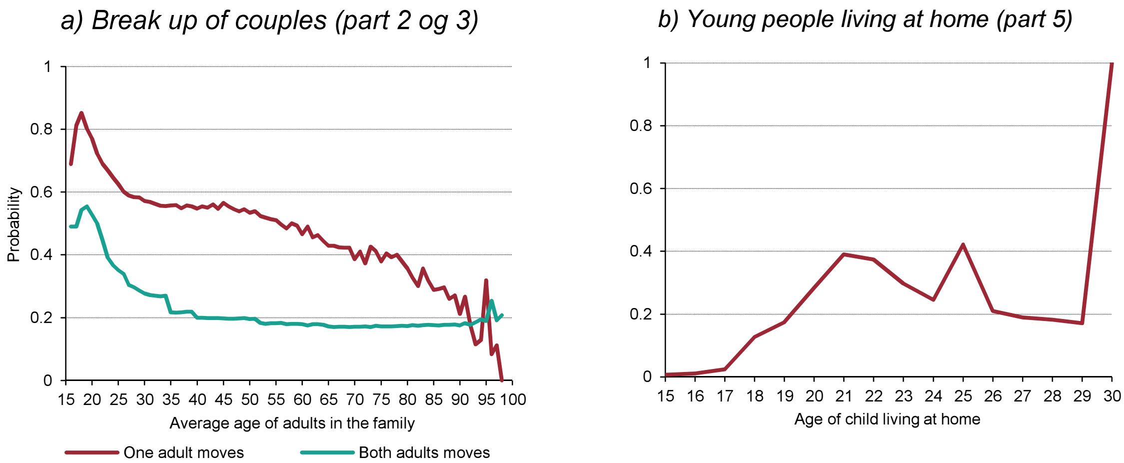
Note: Probabilities are aggregated for terminal groups.

The movement probability is over 40 pct. for persons about 20-years-old and decreasing until approximately 4 pct. about the age of 60-year-old. Hereafter it increases again. We see differences in family types. Single males and females have roughly the same profile. However,

[87] The report on estimated movement and choice of dwelling probabilities happen in aggregated form. For an age profile this mean that the number of persons (moving in total respectively) in all terminal groups characterized by a given age are aggregated. So a probability common for all terminal groups where persons have a given age is reported. The report will therefore not express variations in probabilities that can be found further down the tree.

females are more likely to move at the beginning of their 20s. Couples have a similar profile, but the movement probabilities are lower for all ages. Couple differ also by having their movement probabilities close to 3 pct. from age 50-years-old and onward.

Figure 3.10. Estimated movement probabilities by the break-up of couples and moving away from home, 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are aggregated for terminal group. The probability for moving away from home increases considerably by the 25 year. The reason is the expansion of the age interval for children living at home is not completely identical with the Statistics Denmark's definition of the same.*

The movement probability is high for persons that experience a break up for couples, cf. Figure 3.10. The probability for both are moving is decreasing, especially until the middle of the 30s, where is becomes relatively stable around 15–20 pct. Then we have the probability for one of the persons move. This probability is higher than 50 pct. for persons until 60 years and is equally decreasing the higher the age.

The probability for children living at home to move away is increasing from 15 to 21 years; hereafter it is decreasing. We assume all 29-year-old living at home move out, as persons at 30-years-old and above liv away from their parental home per definition, cf. footnote 79.

3.4. Choice of dwelling

When the Danes make a decision to move, they also make a choice of dwelling. How much will they spend on this dwelling in Danish kroner? Will it be an owner-occupied dwelling, a cooperative dwelling or a form of rented dwelling? Will the dwelling be a detached house, a terraced house, an apartment or something completely different, and how large will it be? Where will the dwelling be located? In other words, a set of questions has to be answered in connection with movements. Making a decision to move and then choice of dwelling sequentially build the housing module. The choice of dwelling probabilities are therefore estimated under the condition of a decision have been made to move to a new dwelling based on the period 2000–2010.

3.4.1. The Danish housing market

The choice of dwelling has to be seen in connection with the movement pattern over a life course. Young people will often choose a rented dwelling while they study and at the beginning of their careers on the labour market. An owner-occupied dwelling will be attractive at a later point. At the same time, household specific events can affect the choice, which also must be seen as limited by the economic range of the households.

In Skifter Andersen (2011), the Danes' motives of choice of dwelling and the choice of ownership and rental especially are analysed[88]. The owner-occupied dwelling as a long-term investment is a central motive, but the choice is affected by many other factors. Deductions for interest costs represent a more short-term motive for investing in an owner-occupied dwelling. Freedom to dispose of the dwelling, flexibility and security are identified as non-economic motives to choose an owner-occupied dwelling. Motives vary among ages, family types, labour market status, location etc.

The actual choices of dwellings are described in Kristensen (2011), who look at choices of location, ownership and rented dwellings, detached houses, multi-dwelling houses etc. during the last decade. The analysis calculates the net movement of young people below 30 years. The provinces of Central Copenhagen and East Jutland stand apart with a relatively high net influx of young people below 30-years-old. In general, this applies to areas with more than 100,000 inhabitants. Adults have another behaviour as these provinces and areas experience a net vacation of persons above 30-years-old. Also it appears that young peoples' choice of dwelling often is characterized by being rental dwellings, especially privately owned rented housing in multi-dwelling houses. Adults often choose owner-occupied dwellings or privately owned rented housing, which category is detached houses or multi-dwelling houses.

Table 3.2. Number of movements for persons in the population, 2000–2010.

	Person experience:		Population:	Number of persons:	
	Brake-up of couple	*Formation of couple*		*2000–2010*	*Avr. per year*
Adults	No	No	Part 1[1]	584,500	53,136
	Yes	No	Part 2	574,869	52,261
	Yes	Yes	Part 3[2]	85,348	7,759
	No	Yes	Part 4[2]	1,012,490	92,045
Living at home	-	No	Part 5	674,895	61,354
	-	Yes	Part 6[2]	190,760	17,342

Source: *Own calculations based on register data from Statistics Denmark.*

Note: *The population only includes persons where all dwelling characteristics are known for both the dwelling they move away from and the dwelling they move into. People that cannot be characterised due to an unknown address are not included in the housing model (part 7). Deviations in number of persons relative to Table 3.1 are due to a condition of characteristics of a dwelling moved to must be known.*

Note 1: *The persons in part 1 are drawn from a simple random sample without replacement (20 pct.).*

Note 2: *Choice of dwelling probabilities is estimated for all persons, whether they move or not. This is due to a simulation technical detail, where persons in this part of the population have a possibility to choose the present dwelling.*

3.4.2. Strategy for estimation

The choice of dwelling is expressed by characteristics for the dwelling moved to in connection with movements. A choice of dwelling is defined as a decision to move to another dwelling that is

[88] The analysis uses a questionnaire from 2008, containing 2.500 Danes over a period of 15 years. 60 pct. of these have expressed preferences for their use of dwellings.

characterized by location (province and city size), ownership and rental conditions (dwelling type), category (physical use), area (dwelling size) and construction year (dwelling age). The simulation model determines the choice of dwelling from probabilities to move into a dwelling with given characteristics.

Following chapter 3.3, the choice of dwelling probabilities for the parts of the population on the housing market dependent on events in the family structure. Firstly, the probabilities are estimated for those persons that neither experience formation nor break up of couples (par 1), cf. **Table** 3.2. Then the probabilities are estimated for persons that experience the break-up of couples without forming a new couple (part 2). Thirdly, the probabilities are estimated for persons that form a new couple, whether they experience a break up beforehand or are young people living at home (part 3, 4 and 6). Fourthly, the probabilities are estimated for young people moving away from home without forming a new couple (part 5).

Choice of dwelling probability

The choice of dwelling probabilities for person i is conditioned by a movement happens during year t. The probabilities are estimated using a successive approach, where persons choose one characteristic at a time. The hierarchy for choice of dwelling are set as follows[89]:

$$\underbrace{\text{Province}}_{dwPro} \rightarrow \underbrace{\text{Dwelling type}}_{dwType} \rightarrow \underbrace{\text{Dwelling category}}_{dwCat} \rightarrow \underbrace{\text{Dwelling size}}_{dwSize} \rightarrow \underbrace{\text{City size}}_{dwCity} \rightarrow \underbrace{\text{Dwelling age}}_{dwAge} \qquad (3.3)$$

Decision trees are constructed on the basis of household and dwelling characteristics for the dwelling moved away from ($\boldsymbol{x}_t$), where F persons move in a part of the population is partitioned in a number of terminal groups. The trees for all parts of the population are built with a CTREE and input variables with the same characteristics that is used for the movement probabilities. The starting point for variables is therefore:

- Age
- Family type and gender
- Educational background
- Origin
- Labour market status
- Children in the household
- Province of residence
- Dwelling type
- Dwelling category
- Dwelling size
- City size
- Dwelling age

The successive approach implies that already chosen dwelling characteristic for the dwelling moved to also are included in the decision trees. As indicated earlier, the choice of dwelling is limited for the economic scope of the household. This is not included in the input variable for income, capital assets or the like, as the simulation model at the present state does make this possible. However, the characteristics such as education, age and labour market affiliation will to some extent reflect the economic scope of the household.

---

[89] This has been tested by simulating the model using different hierarchies.

As the first thing, the choice and province is estimated by two probabilities. The conditioned probability for moving to another province is based on F moving persons. Then follows the probability to move to another province, given the person moves across provinces:

$$Pr\left(dwPro_{i,t} \neq dwPro_{i,t+1} \middle| \boldsymbol{x}_{i,t}\right), \qquad i = 1, \dots, F \leq N,$$
$$Pr\left(dwPro_{i,t+1} \middle| \boldsymbol{x}_{i,t}, dwPro_{i,t} \neq dwPro_{i,t+1}\right) \tag{3.4}$$

In the second level, the choice of dwelling type is estimated, conditioned by the choice of province. This is also estimated by probabilities; the probability for moving to another dwelling type is used and followed by the conditioned probability for moving to a given dwelling type:

$$Pr\left(dwType_{i,t} \neq dwType_{i,t+1} \middle| \boldsymbol{x}_{i,t}, dwPro_{i,t+1}\right),$$
$$Pr\left(dwType_{i,t+1} \middle| \boldsymbol{x}_{i,t}, dwPro_{i,t+1}, dwType_{i,t} \neq dwType_{i,t+1}\right) \tag{3.5}$$

The choice of dwelling category is determined in the third level with the probability for moving to a given dwelling category conditioned by the choices of province and dwelling type:

$$Pr\left(dwCat_{i,t+1} \middle| \boldsymbol{x}_{i,t}, dwPro_{i,t+1}, dwType_{i,t+1}\right) \tag{3.6}$$

The dwelling size is determined on the fourth level in a similar way with a conditioned probability for dwelling area:

$$Pr\left(dwArea_{i,t+1} \middle| \boldsymbol{x}_{i,t}, dwPro_{i,t+1}, dwType_{i,t+1}, dwCat_{i,t+1}\right) \tag{3.7}$$

The choice of location is expressed by two characteristics. The dwellings' location in the provinces characterise the choice on an overall level. The city size for the dwellings' area will characterise the choice on a more local level. The choice of city size on the fifth level is estimated by a conditioned probability and can be interpreted as population density:

$$Pr\left(dwCity_{i,t+1} \middle| \boldsymbol{x}_{i,t}, dwPro_{i,t+1}, dwType_{i,t+1}, dwCat_{i,t+1}, dwArea_{i,t+1}\right) \tag{3.8}$$

Finally, the choice of dwelling age is determine on the sixth level. The conditioned probability for choosing a dwelling with a given construction year is therefore estimated:

$$Pr\left(dwAge_{i,t+1} \middle| \begin{array}{l} \boldsymbol{x}_{i,t}, dwPro_{i,t+1}, dwType_{i,t+1}, \\ \quad dwCat_{i,t+1}, dwArea_{i,t+1}, dwCity_{i,t+1} \end{array}\right) \tag{3.9}$$

3.4.3. *Choice of dwelling probabilities*

In this chapter, the housing module's estimated choice of dwelling probabilities will be reported. A choice of dwelling probability indicates the probability for choosing a dwelling with certain characteristics, given that movement occur. The probabilities are presented in the order they are estimated.

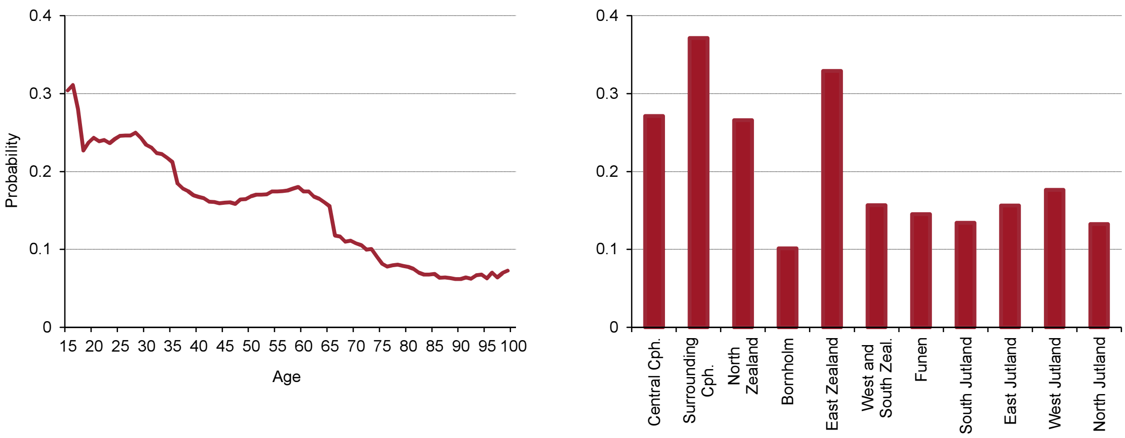
Province of residence

Adults and young people living away from home that neither experience the formation or break up of couples (part 1 of the population) have an overall probability of 20 pct. for moving to another province. Figure 3.11 shows how the probability varies by age and province vacated from. The movement probability is highest until the end of the 30s and decreasing towards the age of 40-

years-old. Then it increases until about 60-years-old, where it again decreases. The tendency to choose another province is highest in the province in and around Copenhagen.

Figure 3.11. Estimated probabilities for moving to another province (part 1), 2000–2010.

a) The whole country distributed by age | *b) All ages distributed by vacated province*



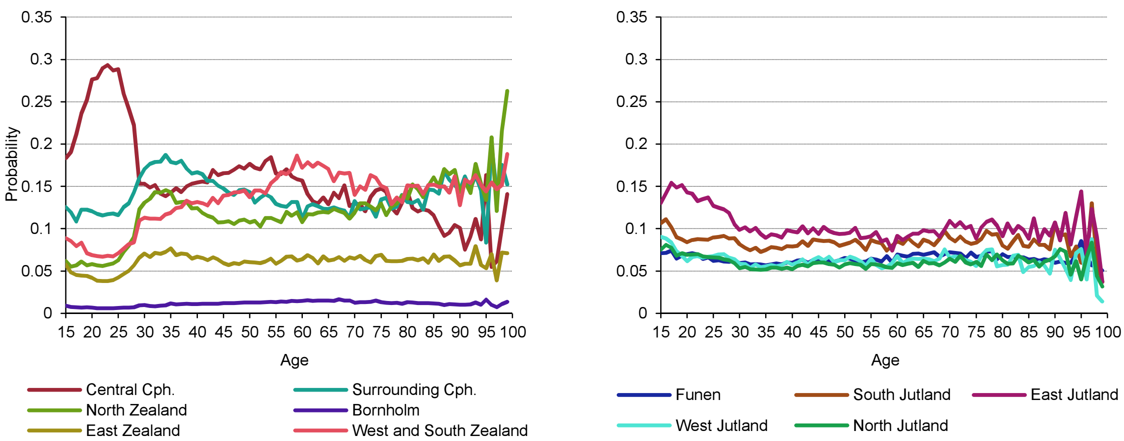
Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate vacated province.*

For persons that neither experience the formation nor break up of couples (part 1), the choice of province often fall on Central and Surrounding Copenhagen and East Jutland, cf. Figure 3.15. However, they generally have a tendency to choose a neighbour province as stated in appendix A.3. In North Jutland, people are most likely to move to East or West Jutland, while Central Copenhagen has the third highest probability.

According to Figure 3.12, persons in their 20s often choose the province of Central Copenhagen, while persons in their 30s often choose the Surrounding Copenhagen. In their 40s and 50s, persons' probabilities for choosing Central and Surrounding Copenhagen is increasing and decreasing respectively. The probability for moving to West and South Zealand is generally increasing with age. For North Zealand, the probability is relatively high in the 30s and from 60 years and onward. There is no significant variation by age in the other province, when you disregard persons in their 20s.

Figure 3.12. Estimated probabilities for moving to a given province (part 1), 2000–2010.



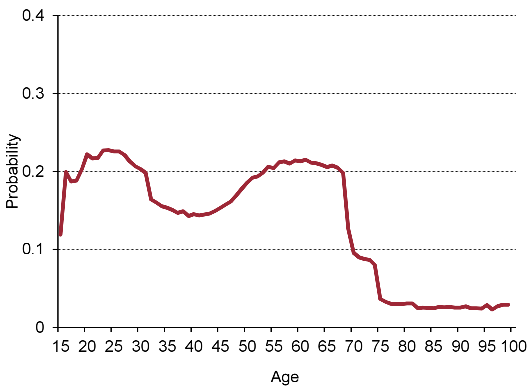
Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by a movement occur across provinces and they are aggregated for terminal groups. Curves indicate influx province.*

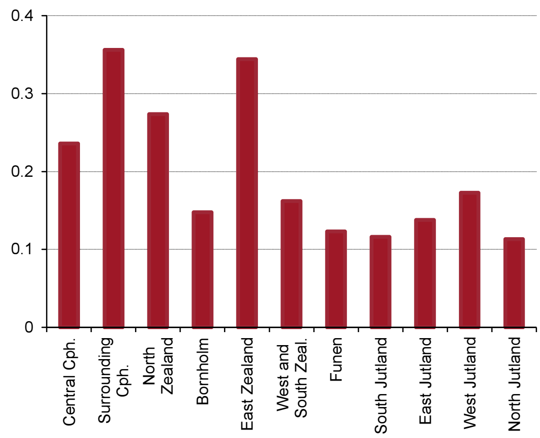
For adults and young people living away from home that experience a break up of couples without forming a new couple (part 2), the probability of moving to another province is estimated to 18 pct. It is highest for persons in their 20s and decreasing until the middle of their 40s, whereby it increases to a relatively high level around 60 years. This is shown in Figure **3.13**, which also show the distribution by vacated province. The probability for choosing a given province for adults that experience a break up of couples without forming a new couple (part 2) corresponds to the probability for part 1, cf. Figure 3.15.

Figure 3.13 **Estimated probabilities for moving to another province (part 2), 2000–2010.**

a) The whole country distributed by age



b) All ages distributed by vacated province



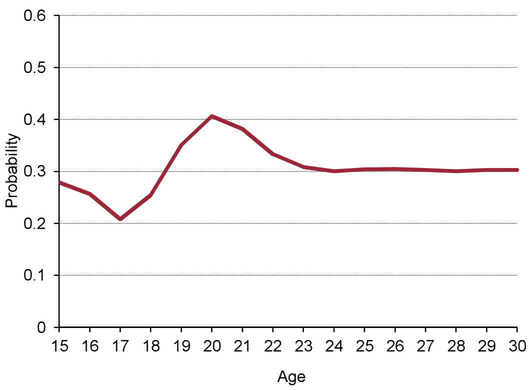
Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate vacated province.*

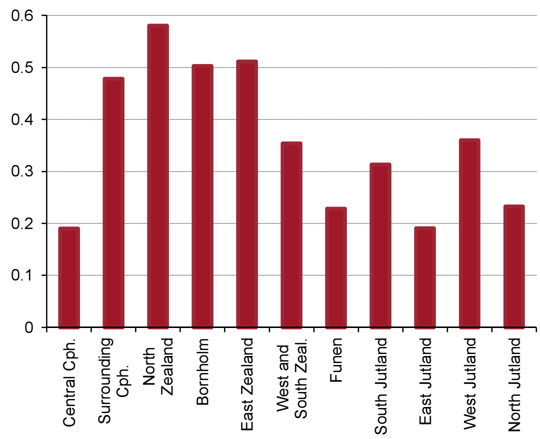
Children and young people that move away from their parental home (part 5) choose another province in 34 pct. of the cases. The probability for moving to another province tops for the 20-year-old and is relatively high for young people in the provinces around Copenhagen and around East Jutland, cf. Figure 3.14. Figure 3.15 also show that young people preferably move to Central Copenhagen and East Jutland, when they move away from home to another province.

Figure 3.14. Estimated probabilities for moving to another province (part 5), 2000–2010.

a) The whole country distributed by age



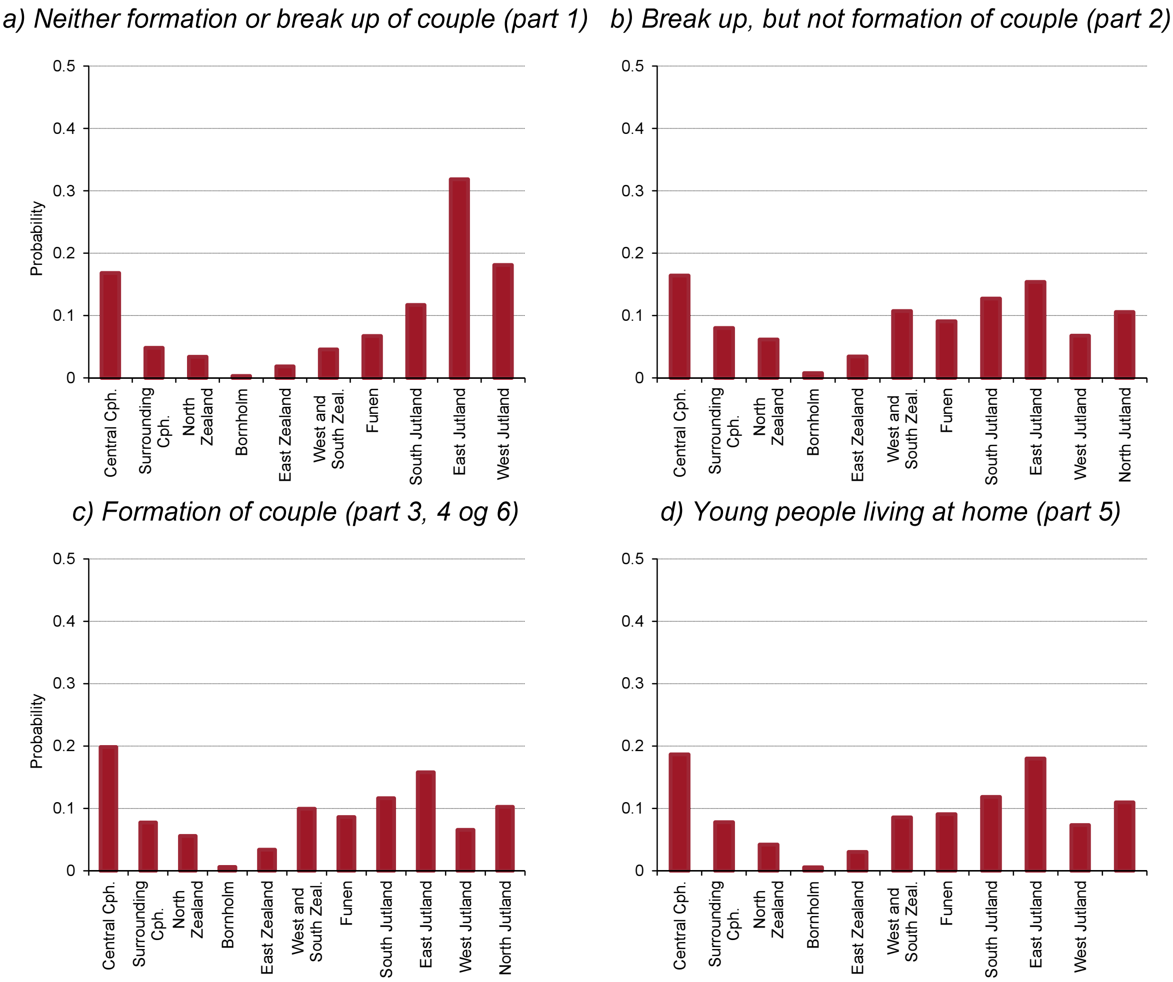
b) All ages distributed by vacated province



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate vacated province.*

Figure 3.15. Estimated probabilities for moving to a given province, 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate vacated province.*

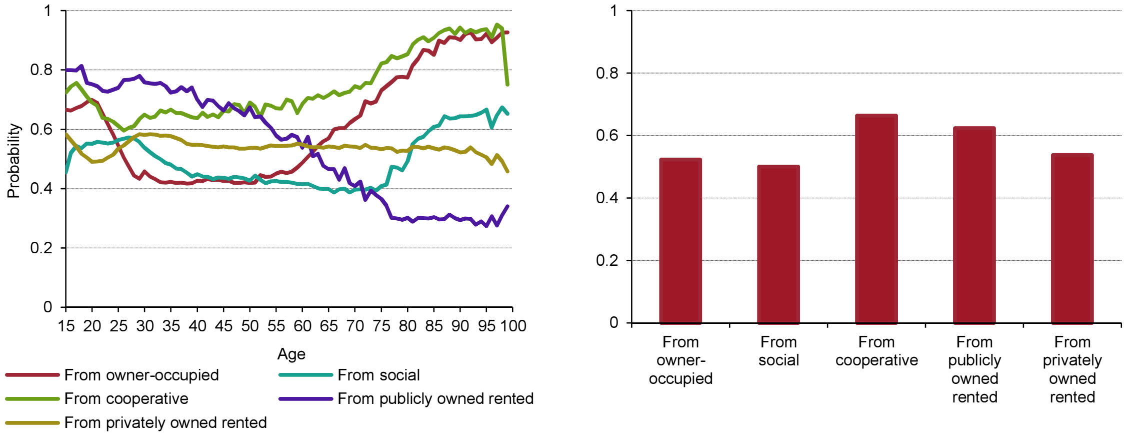
The choice of province is estimated by one probability for persons that experience formation of couples (part 3, 4 and 6). The probability for choosing a given province is similar to the distribution of the other adults and young people living away from home, cf. Figure 3.15.

Dwelling type

The probability for moving out of an owner-occupied dwelling for another dwelling type is estimated to 52 pct. for those persons that neither experiences the formation nor break up of couples (part 1) and who actually move, cf. Figure 3.16. The age profile shows the movement probability from an owner-occupied dwelling is about 40 pct. in the age interval from 30-years-old to nearly 60-years-old, where it becomes increasing. For cooperative dwellings, the probabilities is 66 pct. overall. It is increasing already from before 30-years-old. The probability for moving out of social housing is lower (50 pct.) and decreasing by age until the end of the 70s, where it increases. Privately owned rented housing are characterised by a stabile probability for moving out that across of age vary between 46 and 58 pct. The probability is slightly decreasing through the 30s and then become fairly constant. There is no significant rise in the probability for moving out in the high age steps for this dwelling type. Finally, we have a probability for the publicly owned rented housing that decreases significantly from 80 pct. in age 20-years-old to about 30 pct. for the high age steps.

Figure 3.16. Estimated probabilities for moving to another dwelling type (part 1), 2000–2010.

a) The whole country distributed by age *b) All ages distributed by vacated dwelling type*

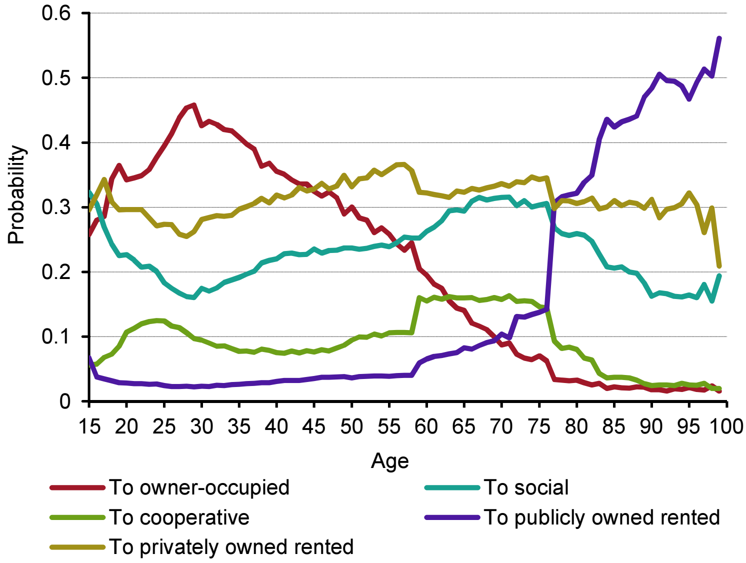


Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns and curves indicate vacated dwelling type.*

In Figure 3.17 and Figure 3.19, the probability for moving to a given dwelling type is shown for the households that move between dwellings. Around age 30, approximately 40 pct. of the persons in part 1 choose to move to an owner-occupied dwelling, followed by social housing (approximately 17 pct.) and cooperative housing (approximately 10 pct.). Towards 60-years-old, we primarily see changes displacements between owner-occupied housing and social housing. The probability for moving to a new dwelling decreases rather much for owner-occupied housing, while it increases for social housing. In the high age steps, publicly owned rented housing is the most frequent choice of dwelling type, probably because the persons move into senior housing. The displacement should be seen in connection to the significant increases in the probability for moving out of an owner-occupied, cooperative and social housing at this stage in life.

Figure 3.17. Estimated probabilites for moving to a given dwelling type (part 1), 2000–2010.

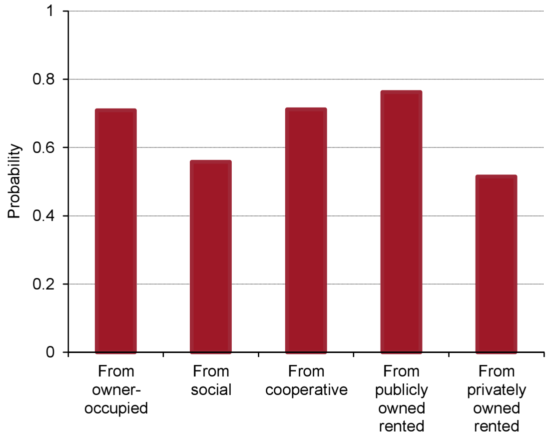


Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Curves indicate dwelling type moved to.*

For persons in part 2, the probabilities for moving out of a given dwelling type is high compared to persons that do not experience the break-up of couples. For example, persons in owner-occupied housing will move to a form of rented housing in approximately 70 pct. of the cases, cf. **Figure** 3.18. In cooperative and social housing, that probability is 71–76 pct. According to **Figure** 3.19, privately owned rented housing is the most common choice of dwelling among persons in part 2 that move between dwelling types.

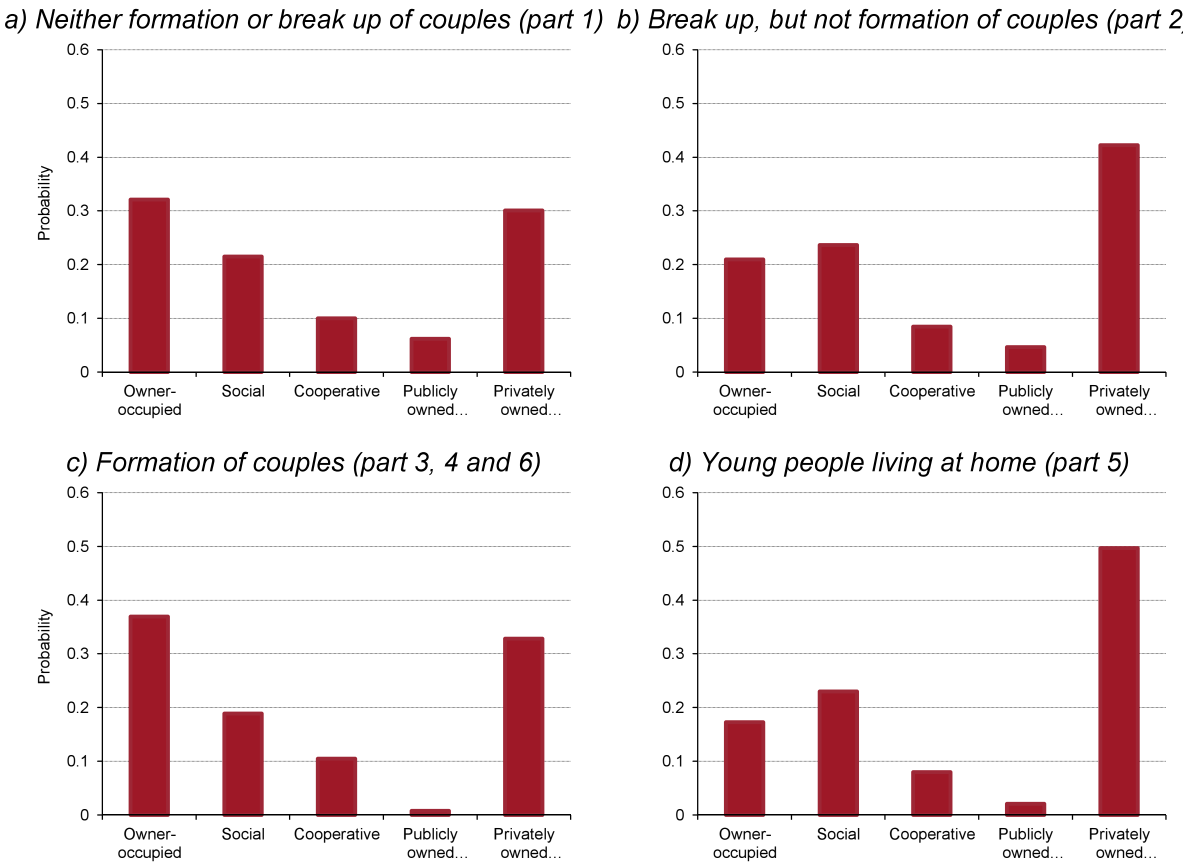
Figure 3.18. Estimated probabilities for moving to another dwelling type (part 2), 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate vacated dwelling type.*

Figure 3.19. Estimated probailities for moving to a given dwelling type, 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

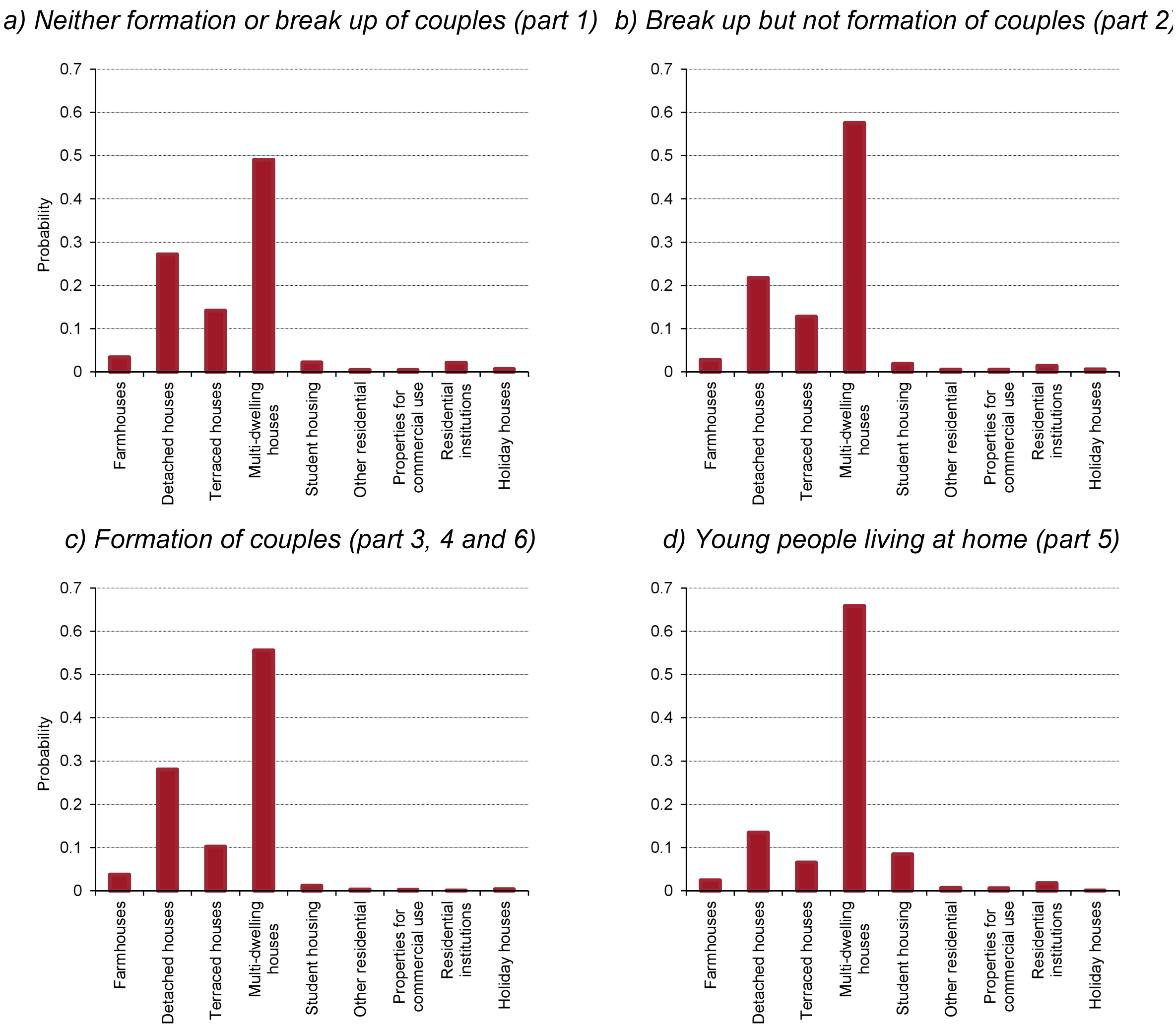
Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate the vacated dwelling type moved to.*

For adults and young people living away from home that experience a formation of couple, the choice of dwelling type is estimated by one probability, i.e. without a conditions of movement to another dwelling type. Among adults and young people living away from home that experience the formation of couple (parts 3, 4 and 6), owner-occupied housing and privately owned rented housing are chosen with the highest probability, cf. **Figure** 3.19. Both are chosen in connection with fairly 30 pct. of the movements. Young people living at home (part 5) choose privately owned rented housing with the probability of 50 pct., when they move away from home. Then follows social housing with roughly 25 pct.

Dwelling category

Multi-dwelling houses are generally the preferred category for the dwelling moved to, cf. Figure 3.20, due to frequent movements between multi-dwelling houses. The probability for choosing a multi-dwelling house lies between 49 and 58 pct. for adults and young people dependent on part of population.

Figure 3.20. Estimated probabilities for moving to a given dwelling category, 2000–2010.



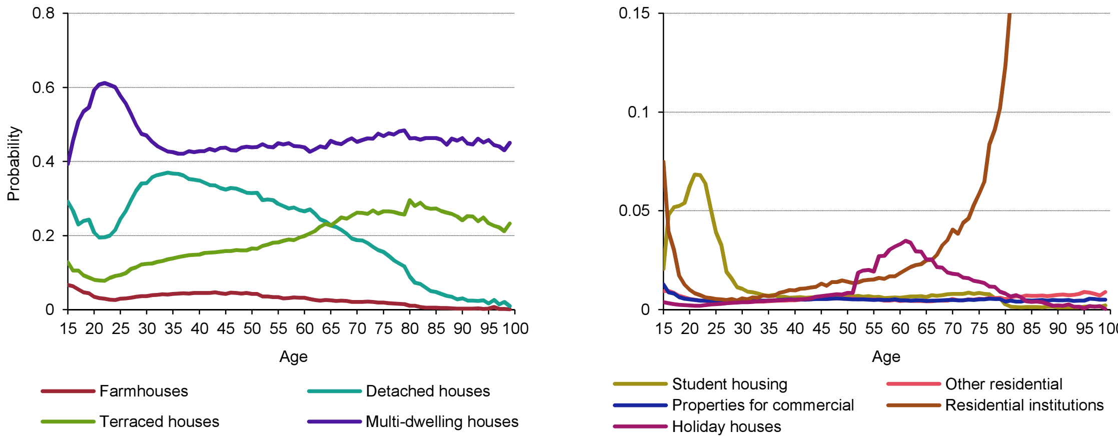
Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate the category of the dwelling move to.*

Detached and terraced houses are together the most common dwelling category, but vacating these dwellings is relatively low. A detached house is therefore chosen by a probability of 22–28 pct. and a terraced or double house by a probability of 10–14 pct. The other dwelling categories are chosen by probabilities, which are lower than 5 pct. When young people living at home move out of their parental home, multi-dwelling houses are their choice in approximately 66 pct. of the cases. Detached houses are chosen by a probability of 13 pct., while student housing is chosen by 8 pct.

The age profiles for the choice of dwelling category is reported in Figure 3.21 for a person that neither experience the formation nor break up of couples. For this group, the probability for moving to a multi-dwelling house is at its highest in their 20s, while the probability for moving into detached and terraced house is relatively low. Most moves to student houses happen during the persons' 20s. Onward to the end of their 30s, the probability for moving to a multi-dwelling house decreases significantly, which apparently happen on behalf of the larger surge towards detached and terraced houses. Hereafter, the probability for moving into a detached house is decreasing by age, while it continues to increase to terraced houses etc. In the highest age steps, the probability for moving into an residential institution including senior homes increase significantly, because many senior homes are registered for this category.

Figure 3.21. Estimated probabilitis for moving to a given dwelling category (part 1), 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

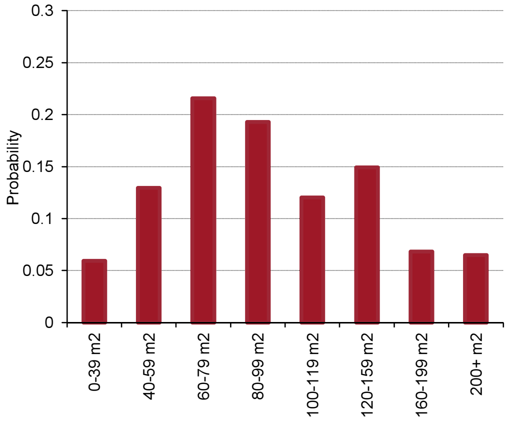
Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Curves indicate the category of the dwelling type moved to. In the figure to the right, the axis is cut at 0.15. The probability for moving to a residential institution is continuously increasing for persons above 80-years-old, and the probability is approximately 0.3 for 100-year-old.*

Dwelling size

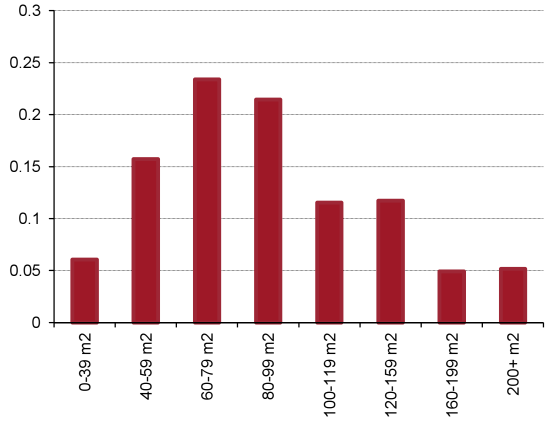
The distribution of the dwelling area, chosen in connection with movements, is shown in Figure 3.22. Dwellings between 60 and 99 m^2 is often chosen among adults and young people living away from home. The choice of dwelling among young people that move out of their parental home is characterized by having a smaller living area. So the probability for moving to a dwelling with an area below 60 m^2 is relatively high.

Figure 3.22. Estimated probabilities for moving to a given dwelling size, 2000–2010.

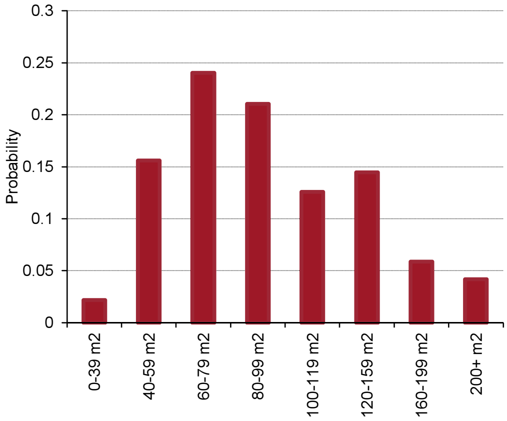
a) Neither formation or break up of couples (part 1)



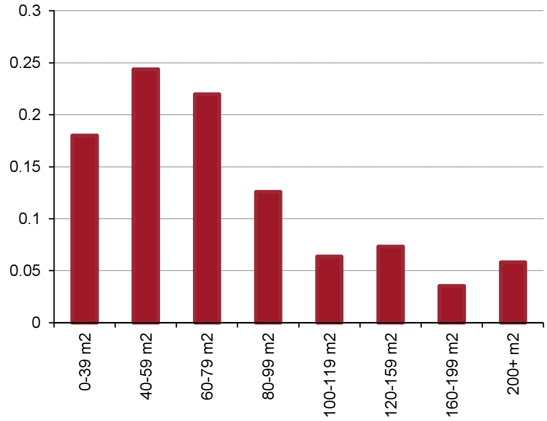
b) Break up but not formation of couples (part 2)



c) Formation of couples (part 3, 4 and 6)



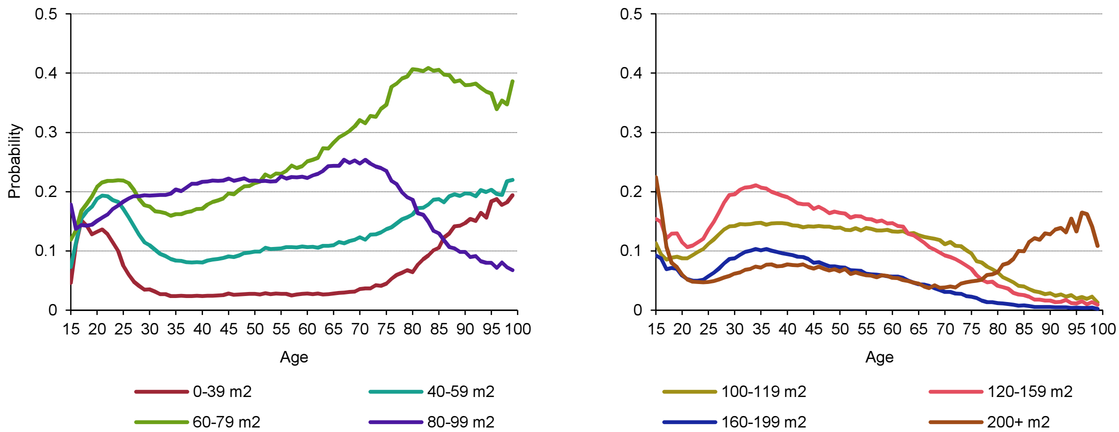
d) Young people living at home (part 5)



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate the size of the dwelling moved to in number of* m^2.

Figure 3.23. Estimated probabilities for moving to a given dwelling size (part 1), 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate the size of the dwelling moved to in number of* m^2.

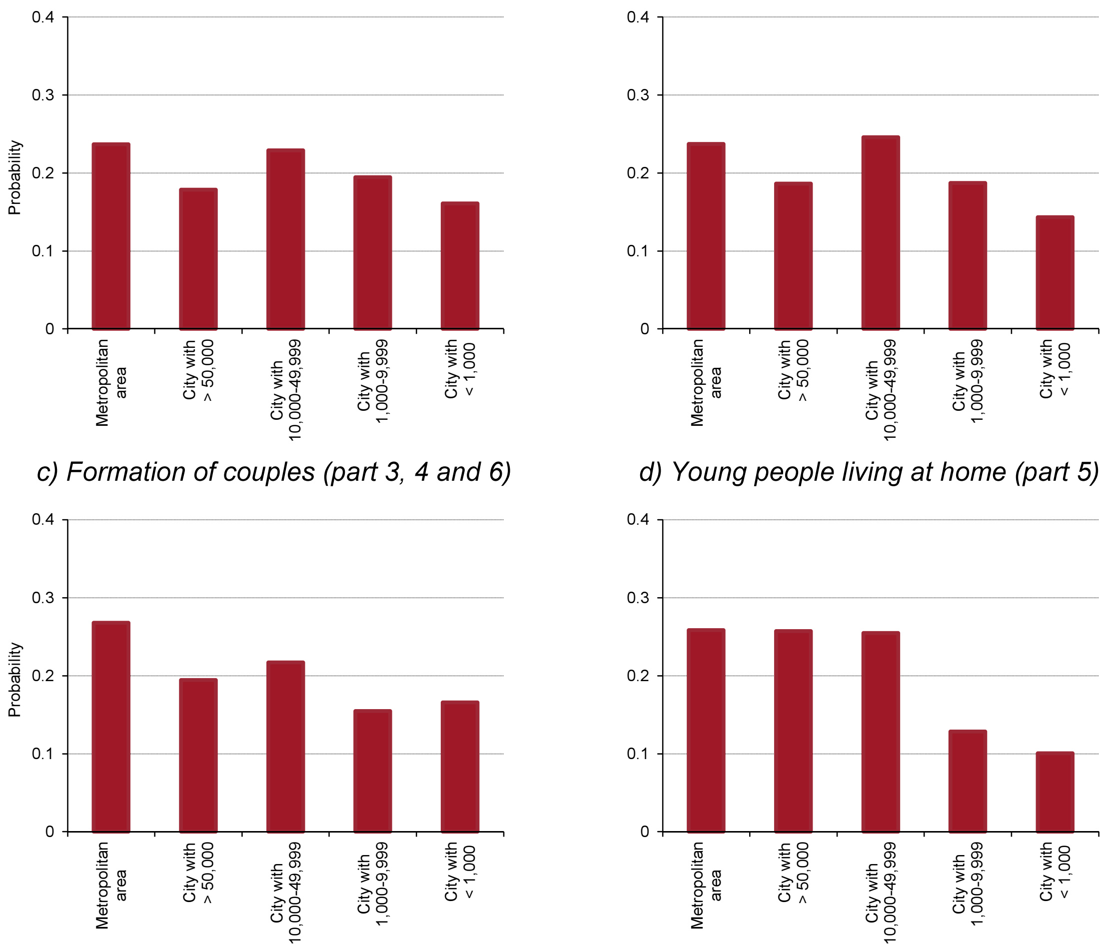
Figure 3.23 show that the choice of dwelling area is conditioned by age for persons that neither experience the formation nor break up of couples. In their 20s, people often move to smaller dwellings with an area of under 80 m^2. However in their 30s, the probabilities for moving to a dwelling of this size at its lowest, while the probability for choosing the larger dwellings of areas at least 100 m^2 is at its highest. From around 40 years, the probabilities for moving to a smaller and larger dwelling respectively move in opposite directions, so the tendency to choose a smaller dwelling increases with age. Also the probability to choose a dwelling with an area of 80–99 m^2 is relatively stable across all ages.

City size

The probability for moving to a given city size is conditioned by the choice of province, which is why we see that adults and young people living away from home are most likely to choose the metropolitan area, cf. Figure 3.24. However, we see no larger fluctuations between the probabilities for moving to a given city size[90].

Figure 3.24. Estimated probabilities for moving to a given city size, 2000–2010.

a) Neither formation or break up of couples (part 1) *b) Break up but not formation of couples (part 2)*



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate the city size of the dwelling moved to in number of inhabitants.*

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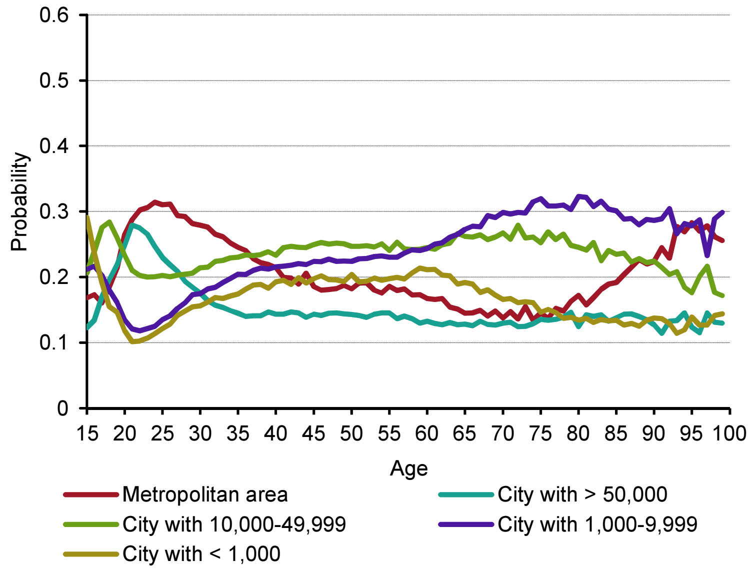
[90] This is the case, when the probabilities conditioned by province moved to are reported. In Figure A.1, we see that the choice of city size depend on the previous choice of province in part 1 of the population. For example, the probability for moving to Central and Surrounding Copenhagen is estimated to close to 100 pct. for persons that choose the province of Central Copenhagen.

The metropolitan area receive adults and young people living away from home by a probability of 24–28 pct. dependent of which part of the population, they represent. Areas with fewer than 1,000 inhabitants represent the least frequent choice of city size (by a probability of 13–15 pct.), when you disregard persons that form couples. Young people living at home who move out tend to seek towards urban areas with at least 10,000 inhabitants.

Figure 3.25 shows the age conditioned probability for moving to a given city size for part 1 of the population. For the metropolitan area and other areas of at least 50,000 inhabitants, the probability for moving to is at its highest in people's 20s and decreasing until their 40s. The probability for moving to the metropolitan area continues to decrease until the high age steps. Areas with fewer than 50,000 inhabitants represent a contrast with a probability for moving to, which is at its lowest in people's 20s and increase by age, when you disregard the high age steps.

Figure 3.25. Estimated probabilities for moving to a given city size (part 1), 2000–2010.



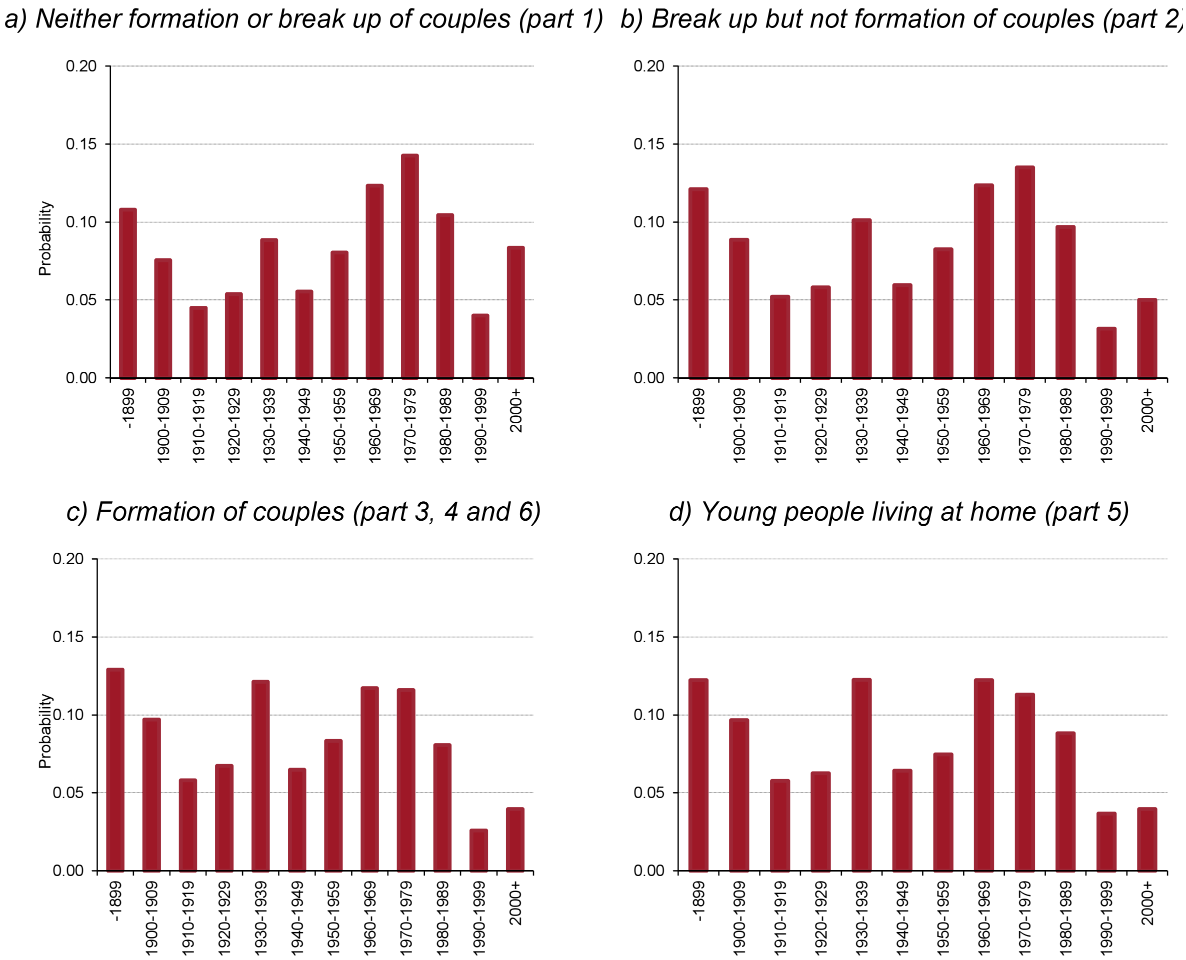
Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Curves indicate the city size of the dwelling moved to in number of inhabitants.*

Dwelling age

The probabilities for moving to dwellings with a given age are estimated on the sixth level and are therefore conditioned by the choices of the dwelling's province, type, category, area and city size. Figure 3.26 shows the distribution of probabilities if the decade of usage. Next, Figure 3.27 shows the age-conditioned probabilities for choosing a given dwelling age.

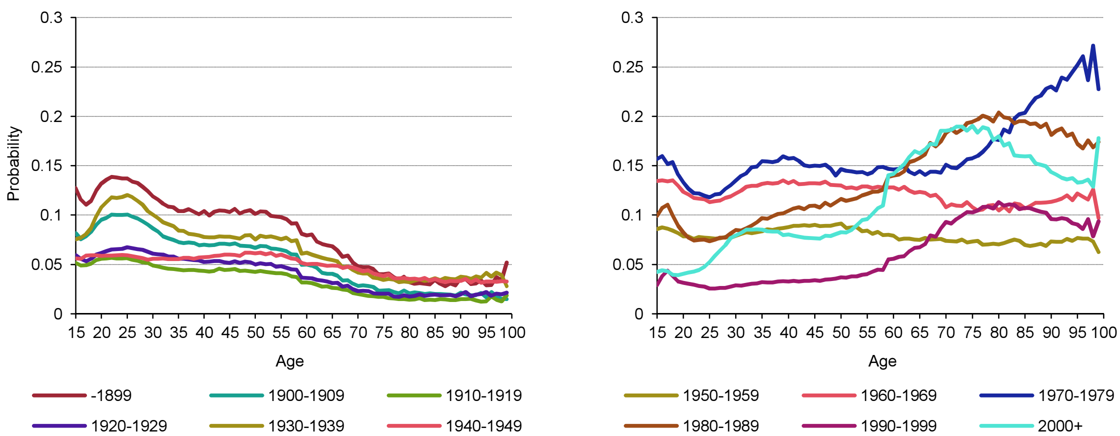
Figure 3.26. Estimated probabilities for moving to a given dwelling age, 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Columns indicate the decade when the dwelling moved to was put to use.*

Figure 3.27. Estimated probabilities for moving to a given dwelling age (part 1), 2000–2010.



Source: *Own calculations based on register data from Statistics Denmark.*

Note: *Probabilities are conditioned by if a movement occur and they are aggregated for terminal groups. Curves indicate the decade when the dwelling moved to was put to use.*

4. Forecast

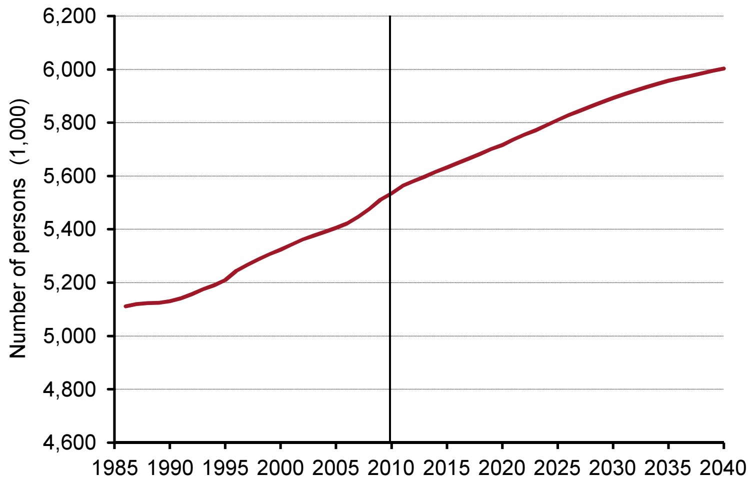
The demographic module and the housing module form the basis for the forecast of the housing demand until year 2040. The demographic module forecasts the development in the overall population and its cohabitation pattern. The result is a forecast of the number of households in Denmark, i.e. we have a projection for the number of single people and couples as well as the number of children living at home for each household. In the housing module, each household is assigned exactly one dwelling. Among other things, the dwelling depends on the size of the household and the age of the adults in the household; for example, families with children will have a tendency to have a larger dwelling than single people. Hereby we have a forecast of the housing demand, which is defined to be the number of dwelling necessary so each household in the population have one dwelling. This is often referred to as the potential housing demand.

In chapter 4.1, the results for the regional population projection in the baseline scenario will be presented. The initial population in 2010 consists of approximately 5.53 million people that with a continued positive population growth is expected to rise to approximately 6 million in 2040. The forecast of the household structure will be presented in chapter 4.2. Households are increasingly expected to be constituted of single people. In chapter 4.3, the forecast of the housing demand on national level will be presented. The forecast substantiates, that the housing demand will rise the following decades. The demand for rented housing is presumed to rise more than the demand for owner-occupied housing, which is why rented housing is expected to form a larger share of the overall housing stock. In appendix A4 we see a table that gives an overview of the main results of the forecast for chosen years. In Appendix A5 we see similar tables for each province. In chapter 4.4, the expected rise in the housing demand is converted to how large housing investments that are necessary to meet the rise in the housing demand.

4.1. The population

The Danish population has grown from 2.4 million people around year 1900 to 5.53 million by the beginning of 2010. There has been a positive growth in the population all the years expect for a short period in the beginning of the 1980s.

Figure 4.1. Total Danish population, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

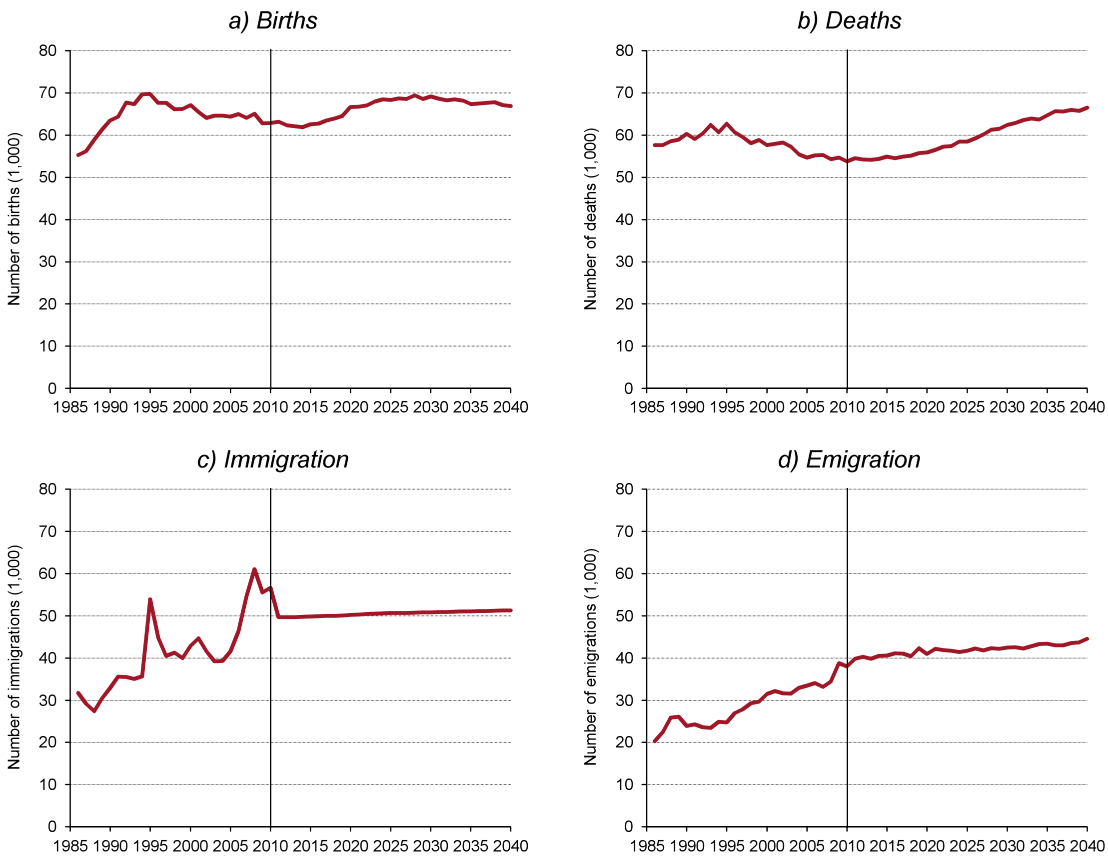
The tendency for an increasing population is expected to continue the coming years, cf. Figure 4.1, which shows the projected development in the population. With the applied projection principles, the overall Danish population will be of around 6 million people in 2040. Onward to 2030, we expect a fairly constant growth of approximately 17,000 people annually in the overall population. After 2030, the population growth is gradually decreasing, and in 2040 the population is largely 8,000 people bigger than the previous year.

Total population increases due to positive net immigration (i.e. we expect a larger immigration than emigration) as well as a positive birth surplus (i.e. more births than deaths).

4.1.1. Demographic events

Figure 4.2a shows the number of births that during the years varies due to the number of females in the childbearing age and variation in the overall fertility. From the small birth cohorts in the beginning of the 1980s, the number of births have risen towards the middle of the 1990s, primarily due to an increase in fertility, after which the fertility have been somewhat constant, and the number of births have been slightly decreasing as we have fewer females in the childbearing age.

Figure 4.2. Number of births, deaths and migrations, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

In the projection, the overall fertility is as good as constant, though with a tendency to be slightly increasing the first 10–15 years, where it then stabilizes. In the first couple of years, the historical tendency to a slightly decreasing number of births continues due to a drop in the number of females in the childbearing age. After which a rise in the number of females in the childbearing age will increase the number of births towards 2025, where the number of births will slightly decrease again.

Since the middle of the 1990s, the number of deaths has been decreasing, cf. Figure 4.2b. This is mainly due to a significant drop in the mortality rate during this period. In the forecast, we expect a continued decrease in the age-conditioned mortalities. The average life expectancy will therefore increase during the projection period, but as the big birth cohorts of the post-war period becomes older, the number of deaths will also increase.

Based on the number of births and deaths, we expect a birth surplus of 8,000–10,000 people annually during the first 15 years of the projection. This is a continuation of the level observed during the latest historical years. In the period from 2025 to 2040, the birth surplus will decrease gradually from about 9,000 to approximately 1,500 people annually.

Since 1986, the number of people that immigrates to Denmark has shown large fluctuations, cf. Figure 4.2c. Over the length of the period, we see an apparent tendency for an increasing immigration. In 2010, the overall gross immigration to Denmark was nearly 57,000 people, of which approximately 18,600 people re-immigrated to Denmark after more than one year abroad. In the projection, we establish first time immigration exogenously to 31,000 people annually, while the re-immigration in the beginning of the projection is 18,000 people annually. The re-immigration is slightly increasing over time, which is why the overall immigration also increases from around 50,000 people in 2011 to nearly 51,300 people in 2040.

Figure 4.2d shows the development in number of emigrants from Denmark. Since the beginning of the 1990s, we see a tendency for an increase in the annual emigration. This tendency is expected to continue in the projection, although the expected increase in the annual emigration tendency will decrease over time.

As stated, the immigration is expected to be considerably larger than the emigration, which leads to a net immigration of 9,000–10,000 persons annually at the beginning of the forecast. After which the net immigration decreases gradually and ends up on around 7,000 people annually in year 2040.

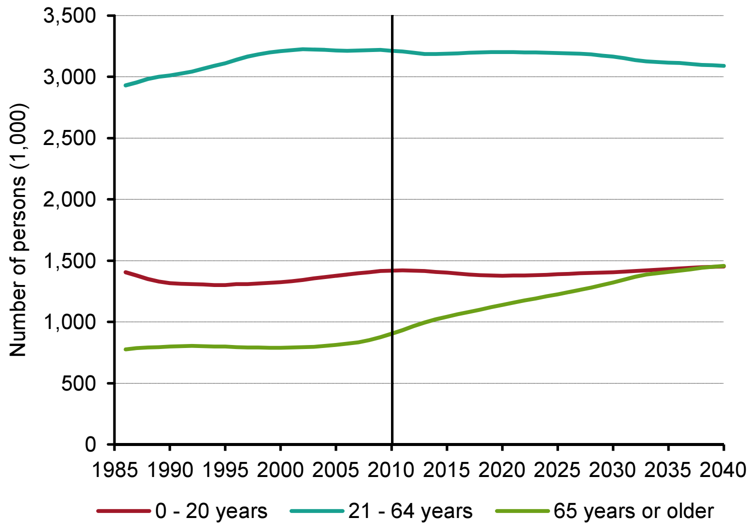
4.1.2. The population's age composition

Figure 4.3 shows the overall population distributed by age intervals. The first interval contains the 0–20-year-old, who typically lives at their parental home. The second interval is the 21–65-year-olds who are potential families with children. The third interval contains persons 65-year-old and older, where eventual children typically will have moved away.

In the projection, the number of 0–20 is somewhat constant. Onward to 2020, the number decreases by roughly 40,000 people, where after the number increases steadily towards the end of the forecast in 2040. The number of persons at 21–64-year-old is somewhat constant the first 10–15 years of the forecast. After 2025, this number decreases toward 2040, where it is roughly 120,000 persons lower than in 2010, equal to a drop of 3.8 pct.

The growing population toward 2040 is therefore seen almost exclusively for the age interval 65-years-old and onward. The number of persons in this age group increases constantly in the period, in the first couple of years in the projection by around 30,000 persons annually. The growth of persons is decreasing over time, so the age group around year 2040 increase by approximately 8,500 persons annually. That the population growth in the age interval of 65-years-old and above is so large is partly connection to the large birth cohorts from the post war period reaching retirement age, and partly because we expect the future seniors to live considerably longer in the forecast than they do today.

Figure 4.3. Total Danish population by age intervals, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

4.1.3. Regional population development

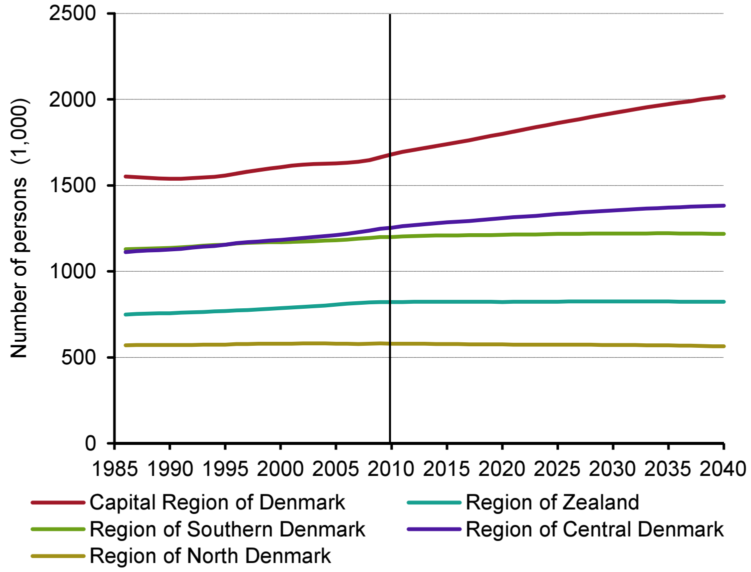
In Figure 4.4, the overall population is distributed by region of residence. As a whole, we expect the influx towards the larger cities to continue in the forecast, as observed in the latest historical years.

The largest region is the Capital Region of Denmark, which consists of the province of Central Copenhagen, Surrounding Copenhagen, North Zealand and Bornholm. Up until the 1990s, the population in Central Copenhagen dropped because of urban renewal, merging of small apartments and people moving to the suburbs, where families with children found more space. In the beginning of the 1990s, this development turned, and a tendency for a population-wise centralization around Copenhagen was observed. The population in the Capital Region have been increasing in the period 1990–2010, where it has grown to nearly 150,000 persons, equal to an increase of nearly 10 pct. In the projection, we expect a continued increase in the population in the Capital Region, so the population in the region increases by just about 335,000 persons in the period 2010–2040, equal to an increase of nearly 20 pct., of which the main part of the population growth is expected to be in the provinces of Central and Surrounding Copenhagen, while a lesser part of the population growth is expected in the province of North Zealand. The population in the Capital Region is increasing due to a net immigration from abroad, a positive birth surplus and a net influx from the rest of the regions. The growing population in the Capital Region increase the share of the overall Danish population living in the region. In 2010, 30.4 pct. of population lived in the Capital Region, while this share is expected to increase to 33.6 pct. in 2040.

The second largest region is the Region of Central Denmark that has grown steadily in population the past 25 years. During the period 1986–2010, the population in the Region of Central Denmark has increased by just about 140,000 persons, equal to an increase of nearly 13 pct. During the past 25 years, the average population growth has been nearly 6,000 persons annually, which is expected to continue in the first part of the projection. Through the projection period, the population growth is decreasing, so the population in the Region of Central Denmark is expected to increase by nearly 130,000 in total in the period 2010–2040 (just about 10 pct.). The positive population growth in the Region of Central Denmark is due to a positive birth surplus and a positive net immigration from abroad. The Region of Central Denmark consists of the provinces of East Jutland and West Jutland, and historically the majority of the population growth has happened in the large urban areas in East Jutland (with a growth of approximately 118,000 persons in the period 1986–2010). This tendency is expected to continue in the projection period, so the region's population growth is expected only to occur in the province of East Jutland, while the population in the province of West Jutland is constant during the projection period. The growing population increase the share of the overall Danish population that live in the Region of Central Denmark from 22.7 pct. in 2010 to 23.0 pct. in 2040.

The Region of Southern Denmark consists of the provinces Funen and South Jutland. In this region the population has been growing throughout the period 1986–2010, and in all, the population increased by just over 72,000 people, or 6.4 percent. The trend of population growth in the Region of Southern Denmark is expected to continue in the projection period, although at a slower pace than in the historical period, and population growth is declining over time. The population in the region increases by just about 17,000 persons in the period 2010–2040, equal to an increase of nearly 1.5 pct. A net emigration to other regions reduces population growth in the Region of Southern Denmark, while a positive net migration from abroad has the opposite effect. The relatively constant population in the Region of Southern Denmark, while the total Danish population is increasing, reduces the proportion of people who are living in Southern Denmark from 21.7 pct. in 2010 to 20.3 pct. in 2040.

Figure 4.4. Total Danish population by regions, 1986–2040.



Sources: Statistics Denmark and own calculations.

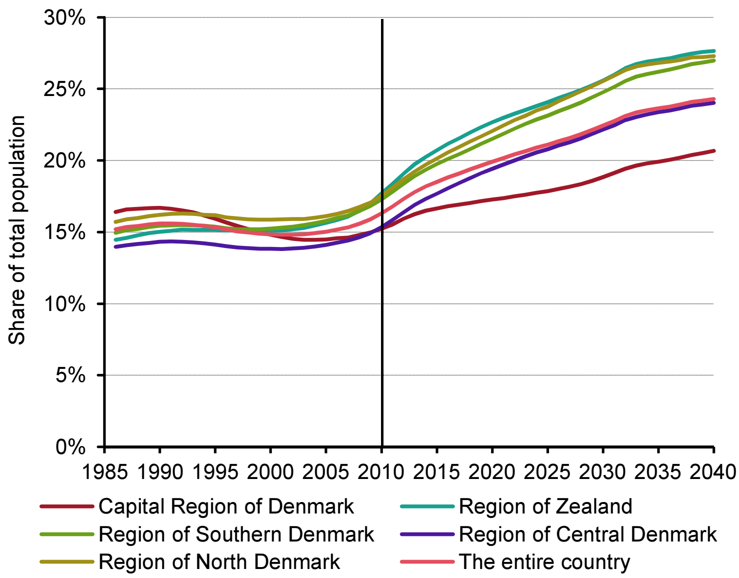
Note: The vertical line indicates the shift between historical data and forecast.

In the Region of Zealand that consists of the provinces East Zealand and West and South Zealand, the population has also been increasing in the historical period. In total, the population increased by 71,500 persons in the period 1986–2010, which corresponds to an increase of 9.5 pct. In the last couple of years in the historical period, the population growth in the Region of Zealand has been quite modest, which is expected to continue in the projection. Toward 2040, the population in the region grows only with about 2,500 persons, equal to an increase of under 1 pct. This cover up an increase in East Zealand of about 9,000 persons, while the population in West and South Zealand is decreasing. During the projection period, the share of the overall population living in the Region of Zealand is reduced from 14.8 pct. in 2010 to 13.7 in 2040.

The Region of North Jutland is the least populated region in Denmark with about 575,000 inhabitants. During the period 1986–2010, the population in North Jutland has largely been constant. This covers up the fact that the population in some periods have been increasing and decreasing in others. During the whole historical period, we see a slightly tendency for increase. In the historical period the population increases by nearly 9,500 persons in total, equal to an increase of 1.6 pct. In the period 2010–2040, we expect a slight decrease in population in North Jutland. Overall, the population decrease by nearly 16,000 persons, equal to a drop of 2.7 pct. The population is especially decreasing due to a net migration to the other regions. By 2010 10.5 pct. of the Danish population lived in North Jutland, and by 2040 the share is reduced to 9.4 pct.

Figure 4.5 shows the share of population that is 65-years-old or older in each of the five Danish regions. During the period 1986–2010, we see the share of seniors be somewhat constant as a whole across the country. However at the end of the historical period, we see a tendency that the share is increasing, as the large birth cohorts of the post-war period reaches the retirement age at age 65. As stated in the previous paragraph, we expect an increase of seniors during the projection period; partly due to the large births cohorts reach the retirement age and partly as a consequence of a considerable increase in life expectancy through the projection period.

Figure 4.5. Share of total population in each region that is 65-years-old or older, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

From 1986 to 2010, the Capital Region of Denmark goes from having the largest share of seniors to having the smallest share (at level with the Region of Central Denmark). This is especially due to the number of persons under 65-years-old has increased, but also because we see a small decrease in the number of seniors in the Capital Region. In the same period, the share of seniors in the other regions increases. In the projection, we expect the Capital Region of Denmark to continue to have the lowest share of seniors. The share is increasing, but to a lesser extent than the other regions. The growth rate for the share of seniors in the Region of Central Denmark roughly follows the country average, while in the Region of Zealand, the Region of Southern Denmark and the Region of North Denmark a considerable increase is expected in the share of persons above 65 of the overall population of the regions.

Overall, the demographic development pulls toward a larger and older population in the coming decades. At the same time, we see an influx toward the large urban areas. The pure demographic development shows us that families with children will make up a smaller share of the overall population in the future, while seniors above 65 years of age will make up a considerable larger share of the population.

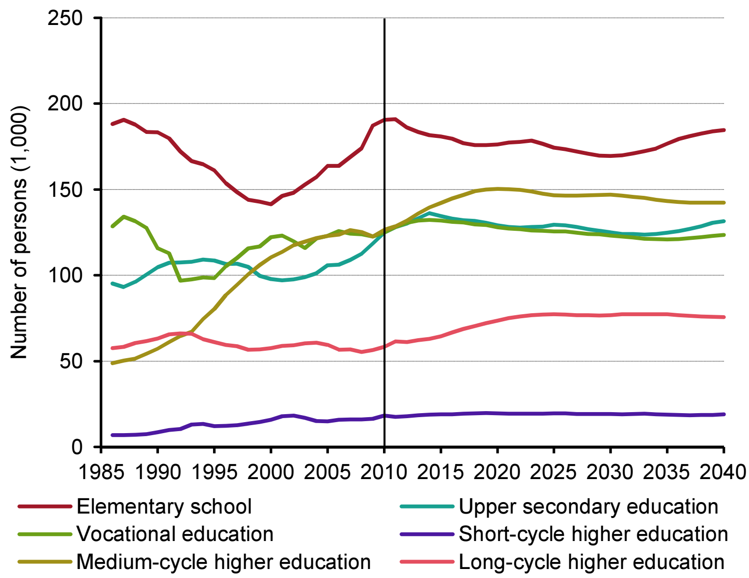
4.1.4. Educational background

The last couple of years, we have seen a clear tendency for an increasing share of each generation of youths start an upper secondary education, of which a larger share will continue on a higher education. The share of unskilled among people in the working ages is therefore decreasing, so the labour force today mainly consists of skilled labour and persons with a higher education. This tendency is expected to continue in the coming years as the younger generations with a relatively high educational level replaces the senior generations, who on average have a lower educational level.

Using the study-related behaviour, which is observed historically, we forecast the number of students at each type of education. The results of the projection will show that future youth generations will have a tendency to choose the same educations, as a similar cohort today.

Figure 4.6 shows the development in the number of students on each type of education. The number of students in elementary school is to a great extent determined by the demographic development, meaning the number of elementary school pupils will decrease toward 2030. After which the number is expected to increase considerably the following ten years. In 2040, the number of elementary school pupils is expected to reach the same level as the number in 2010.

Figure 4.6. Number of persons under education distributed on type of education, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

The development in the number of students on the upper secondary education follows the development in the number of elementary school pupils, only with a couple of years delay. During the projection period, we will to some extent see the same tendency be applicable for the vocational educations.

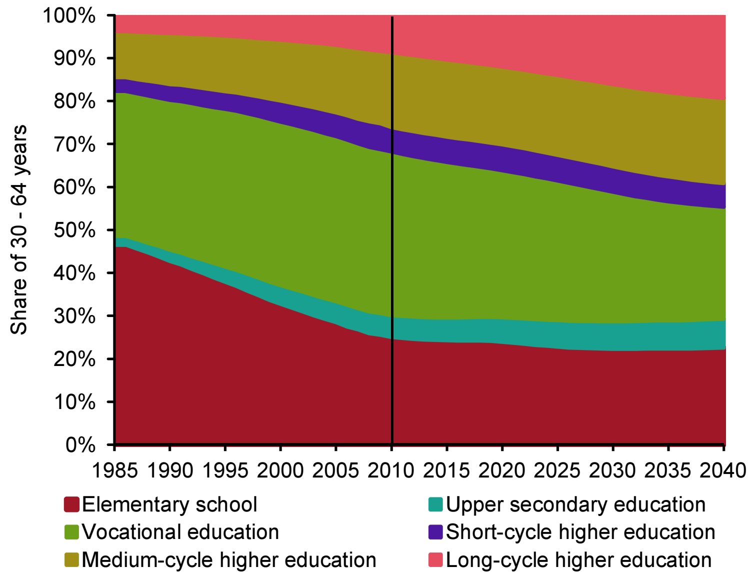
The number of students on the medium-cycle higher educations has been increasing throughout the 1990s and in the beginning of the new century. Due to three factors: Firstly, many long-term university courses are split into a bachelor's degree and a master's degree, where the first is categorised as medium-cycle and the latter as a long-cycle higher education. Because of this change, a large number of students that previously would have studied on a 5-year undivided higher education will instead study the first approximately 3-years on a medium-cycle higher education. Secondly, the number of students on professional educations has increasing during the period, and thirdly, we have more students who begin a university bachelor. From 2005 and onward, the number of students on the medium-cycle higher educations level off, which cover up to opposite effects, partly because the number of students on professional bachelors are decreasing, and partly because the number of students on university bachelors are increasing. Last in the historical period, the number of students on professional bachelors begins to increase again. This tendency is continued in the first ten years of the projection. As the number of university bachelors also is increasing in this period, the number of medium-cycle higher educations increase with about 24,000 persons toward year 2020. Then the number is constant toward 2040, though with a tendency for a drop in the beginning of the period.

In the historical period, the number of students on long-cycle educations is affected by the split of the undivided master's degree into a bachelor's degree and a 2-year-old master's degree. The number of students on a split master's degree is therefore increasing during the whole period from 1986–2010, which is weighed out by a decreasing number of students on the un-split master's degrees that have under 2,500 students in 2010. The overall number of students on the long-cycle higher educations is therefore fairly constant in the historical period. In the first 15 years of the projection, we expect an increasing number of students on the long-cycle higher educations. This is due to an increase in students on university bachelors, which spawn more students to the master's degrees.

At the projection of the educational level, we use the study-related behaviour (as mentioned above) that is observed historically. The result is that the educational level for future generations is not dramatically different from the educational level of the latest generations of graduates in the base year of the projection

The educational level of the overall population can be expressed by considering the potential labour force's highest completed education. The potential labour force age is defined by considering the 30–64-year-old that typically will have completed their education and at the same time is available for the labour market since the old-age public pension is possible from the 65th years of life. Highest completed education is the highest ranked education, which a person has completed. As shown in Figure 4.7, the potential labour force in the projection period will become better and better educated, as the average number of years education is increasing throughout the period. The reason is that the older generations that will leave the potential labour force the coming year have a significantly lower educational level than the younger generations that replace them. The share of persons with a long-cycle higher education especially is seen to increase on behalf of the vocational educated.

Figure 4.7. The population of 30–64 year-olds divided by highest completed education, 1986–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *The highest completed education is shown as a share of the overall population of 30–64-year-olds. Persons with an unknown highest completed education are included in elementary school. The vertical line indicates the shift between historical data and forecast.*

4.1.5. Labour market affiliation

The long-term development in the population's affiliation to the labour market depends mainly of the development in the population's age composition. As stated above, we expect a significant ageing of the population the following years, while we see fewer persons in the present working ages. This leads to a reduction in the labour force and an increase in number of pensioners among other things.

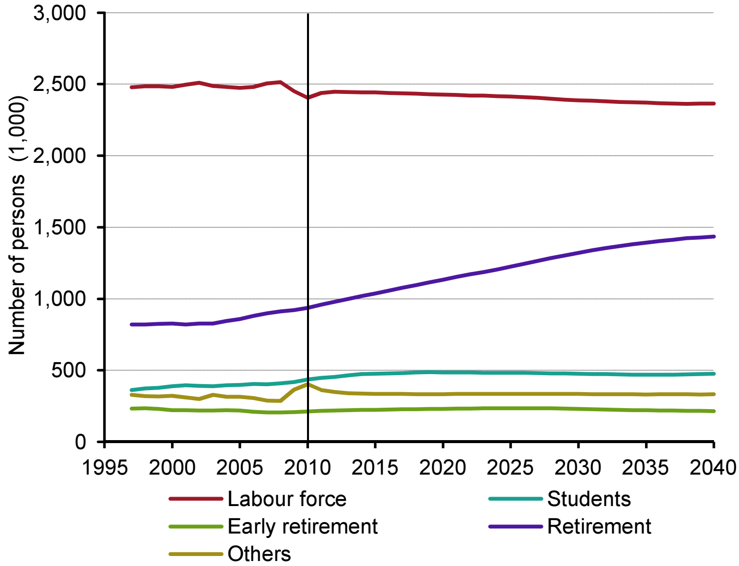
Figure 4.8 shows the population of 17-years-old or older distributed by affiliation to the labour market. The last almost 15 years, the number of persons in the labour force has been fairly constant of about 2.5 million persons. In this period, the labour force is seen fluctuating with the cyclical trends, and at the end of the historical period we see a dramatic drop in the labour force as a consequence of the present crisis. The drop is matched by an increase in the number of person in the "Others" category. This includes categories, where people typically are outside the labour force in short periods. From the middle of the 2000s, the number of retirees from the labour market is rapidly increasing. This is partly connected to a lowering of the pension age, which increases the number of pensioners, and partly that the large birth cohorts of the post-war period reaches the retirement age.

At the beginning of the projection, we see an increase in the labour force of over 40,000 persons within a few years, which come of a normalization of the cyclical situation. We see a similar decrease in "Others" that among others include persons that is outside the labour force for a short period. After which we expect a significant reduction in the number of persons in the labour force for the rest of the projection period. This is caused by the demographic development, where we expect fewer persons in the working ages, cf. Figure 4.3. Furthermore, the number of students increases during the projection period, which equally reduces the labour force (see section 4.1.4.

for a detailed description of the development in number of students). Overall, the labour force decrease by barely 40,000 persons in the period 2010–2040, equal to a decrease of 1.6 pct.

During the period 2010–2040, we see a dramatic increase in the number of persons who are retired from the labour market. In total, this group increase by almost 500,000 persons in the projection period, equal to an increase of over 50 pct. This is due to the demographic development showing a significant increase in the number of persons older than the present pension age in the following decades. This increase follows mainly an increase in life expectancy, but it also cover that the older generations are relatively large compared to the generations in the working ages. I the scope the working ages increase during the projection period; the group of retirees will be reduced.

Figure 4.8. The population divided by labour market affiliation, 17-year-old or older, 1997–2040.



Sources: Statistics Denmark and own calculations.

Note: Other status categories include the categories: “Shortly outside the labour force”, “Temporarily outside the labour force” and “Others outside the labour force”. The vertical line indicates the shift between historical data and forecast.

In the projection, the age conditioned retirement pattern is retained as in the last historical years. There has not been included any effect of already passed labour market politics, including increased retirement age, shortened voluntary early retirement period, reform of early retirement etc. These factors must be expected to influence the development in labour force considerably, cf. Hansen & Hansen (2011).

In the analysis of the housing demand, we include labour market affiliation for choice of dwelling, as the affiliation to the labour market reflects a household’s economic situation to some degree (together with a set of other characteristics such as highest completed education). As the labour market affiliation is only used for choice of dwelling, and only along a long set of other characteristics, then we assess the lack of modelling of passed labour market politics to not have a determining significance for the results of the model.

4.2. Household structure

In the period 1986–2010, the overall population that is 20-years-old or older has grown by 10.3 pct., while the number of families during the same period has increased by 13.5 pct. During the past 25 years there is thus a tendency to the number of families has increased faster than the population growth indicates. If we make a purely demographic projection[91], where the family structure is maintained as in 1986, the number of families in 2010 would have been nearly 95,000 lower than the actual observed number of families in 2010 (equal to 3.4 pct. of the overall number of families). The family structure has actually changed during the period.

The development in the period 1986–2010 covers two opposing effects. Firstly, we see a clear tendency of a decreasing share of persons less than 65 year living as couples, while an equally increasing share lives as single. This effect has several explanations. Young people today are typically studying longer than before. This means, that they at a higher age move together with a partner and form a family. But an increasing share also lives as singles after completed education. This is often explained with an increasing welfare, which makes the single life possible. Secondly, an increasing share of persons above 65 years lives in couples. This effect occurs, because people on average live a longer life. As life expectancy increases, fewer people live as singles, as the time of the partner's death is put out to a higher age. Historically, females have a longer average life expectancy than males, but in the historical period we also see a tendency to that the average life expectancy of males is approaching the average life expectancy for females. This also means that you on average lives fewer years as single after your partner's death.

Figure 4.9 shows the number of families divided by family type. In the period 1986–2010, the number of families increases due to a generally growing population and partly as the family structure in the period changes, so an increasing share of population lives as households with only one adult. The changes in the family structure also mean that we see a larger growth in the number of single families than number of couple families. In the last part of the 1990s and the beginning of the new millennium, we see a temporary tendency to that the number of couple families increase, while the number of single families level off, due to the mortality rate for seniors begin to decrease by the middle of the 1990s, which is why a share of those who would otherwise have stayed single as a consequence of the partner's death instead remain a couple. This effect temporarily dominates the effect of changed family structure, wherein an increasing share of the population lives as singles.

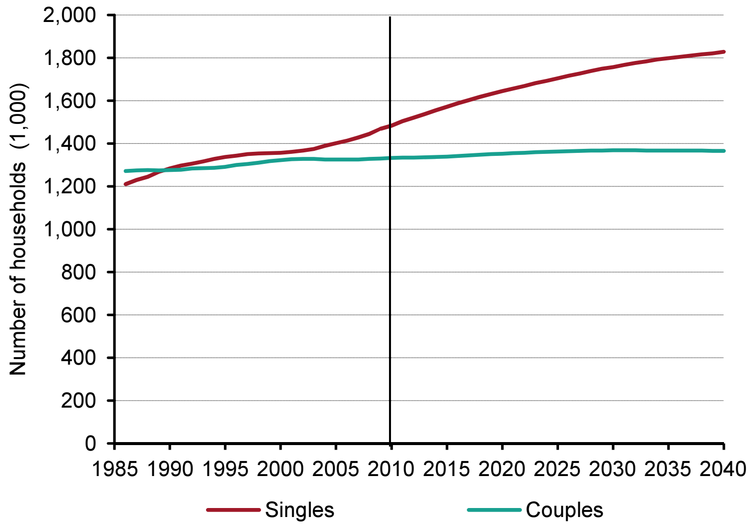
In the projection, the historical tendency of an increasing number of families is expected to continue. Partly because of a growing population and partly as the change in the family structure is expected to continue. As in the historical period, the number of single families grows relatively more than the number of couple families. In 2010, 35.8 pct. of the adult population lived as families of only one adult. In the forecast this number has increased to 40.1 pct. in 2040. The number of single adults is expected to increase by almost 350,000 persons towards 2040, equal to an increase of 23.2 pct. At the same time, the number of adults in couples is assumed to increase slightly by about 70,000 persons, equal to 2.5 pct.

If we make a purely demographic projection, where the family structure for a given age and gender in maintained as in 2010, the number of families in 2040 would have been almost 50,000 families lower than in the projection depicted in Figure 4.9, where the family structure is changed

[91] In a purely demographic projection, the age and gender divided share of the overall number of persons who form a couple is maintained at the same level as in a given year. It is projected, how the number of families would have developed, provided the cohabiting frequency for a given age and gender had been maintained at the level of the given year.

over time. This corresponds to the continuation of the changed family structure in the projection increase the number of families by 1.6 pct. in relation to the pure demographic projection with a maintained family structure as in 2010.

Figure 4.9. Number of families divided by couples and singles, 1986–2040.

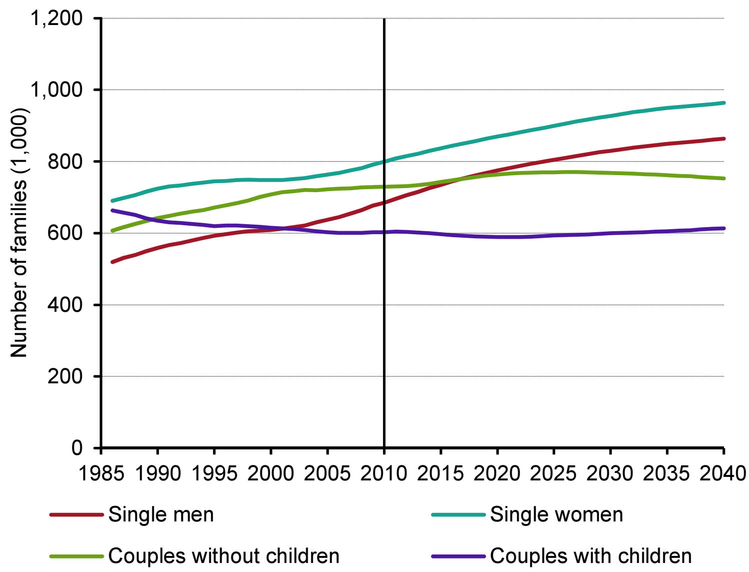


Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

Figure 4.10 shows the number of families divided by family type. As described above, the number of singles increase in the both the historical period and the projection, mainly because of a changed family structure where a larger share lives as singles. The majority of these singles are females, which is caused by a significant overrepresentation of females among the singles above 55 years. The reason for this is that a female's partner typically dies before the female. In the projection, we see a slight tendency to that the number of single males approaches the number of single females. This is caused by the difference in average life expectancy of the two genders is reduced during the projection period.

Figure 4.10. Number of families by family type, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

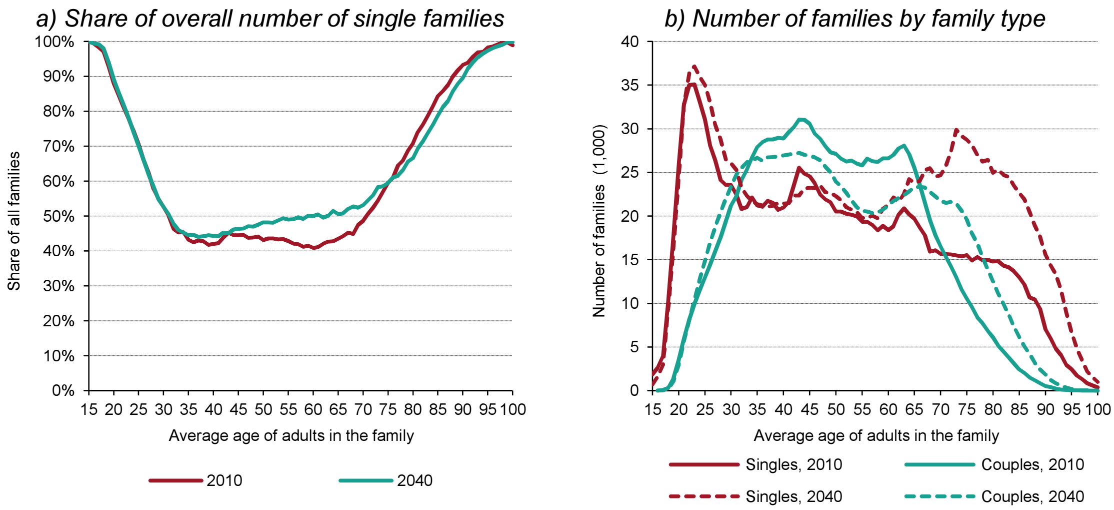
In the period 1986–2010, the number of couple families with children has been decreasing. The decrease has happen as the large birth cohorts of the post-war period no longer have children living at home. Historically, the decrease in the number of couple families with children also has been decreasing. In the projection, the number of families with children is expected to be fairly constant around 600,000. Historically, the number of couples without children has been increasing, as people live longer and therefore form couples for a longer period of their lives. In the last part of the historical years, we see a tendency to a decrease in the growth of couples without children. In the period towards 2030, we therefore expect a smaller increase in the number of couples without children, after which the number is slightly decreasing.

4.2.1. The age composition of households

In the period 1986–2010 the cohabitation pattern have changed, so the share of the overall number of single families has increased from 49 pct. in 1986 to 53 pct. in 2010. As described above, this tendency is continued in the projection, so roughly 57 pct. of all families are expected to include only one adult in 2040.

Figure 4.11 shows the age-conditioned tendency to live as single and couples respectively in the bases year 2010 and in the projection year 2040. Distributed by age, the figure on the left shows the share of the overall number of families containing only one adult. In their prime youth, the majority of the young people not living at home live as singles[92]. For the base year 2010, we see that a large share of the singles moves in with a partner sometime up through their 20s and beginning of their 30s, which is why the share of single families decreases to about 42 pct. This corresponds to nearly 28 pct. of all persons in the age group between 35 and 65 years live as single. The share of single families is somewhat constant from the middle of the 30s towards the present pension age at age 65. After which the share begin to increase as one part of the couple families die. At the end of their lives, by far the majority lives as singles.

Figure 4.11. Age conditioned cohabitation patterns in 2010 and 2040.



Sources: Statistics Denmark and own calculations.

During the projection period, we expect the share of single families in the age group 40–70 years to increase from about 43 pct. in 2010 to nearly 49 pct. in 2040. This is a continuation of the historical tendency to an increasing share of the families lives as single. Historically, the share of

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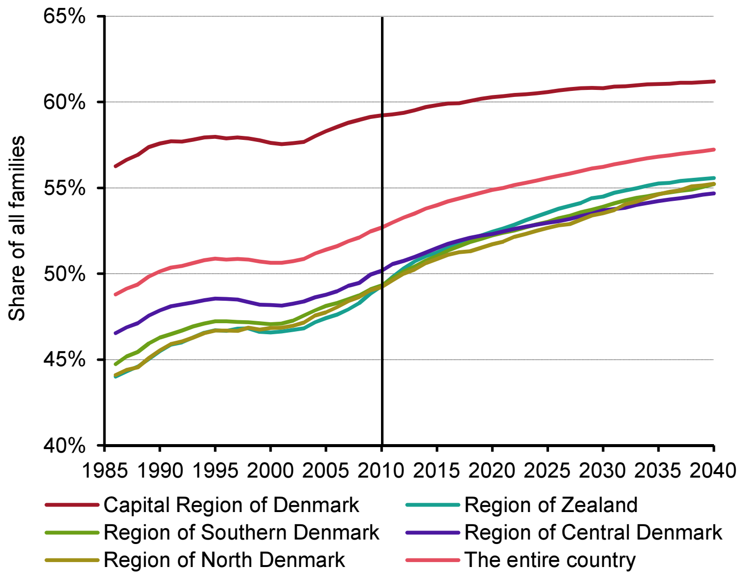
[92] In the model, children living at home can at the earliest move away from home as 15-year-olds, and all children living at home must move away the year they run 30 years at the latest.

40–50-year-old families that include only one adult increase from 32.8 pct. in 1986 to 38.8 pct. in 2000 and to 43.8 pct. in 2010. During the projection period, this increase continue to 45.4 pct. in 2020 and 46.0 pct. in 2030, where after the share stabilizes. The increase in the share of single families in the projection period corresponds to that the share of single persons in the age group 40–70-year-old increase from 28 pct. in 2010 to 32.4 pct. in 2040. The increase rate is highest in the first year of the projection (and at the same level as observed historically) and decreasing in the middle of the projection period to be almost constant at the end of the projection. For families above 70 years, we see a decrease in the tendency to be single, due to the increasing life expectancy, which postpones the time of death for the first person in a couple. This is also a continuation of the historical tendency. In 1986, 72.8 pct. of the families with an average age of 70 years or more lives as single, which is reduced to 63.8 pct. in year 2010.

If we consider the development in the actual number of families, we see that the number of families consisting of singles in the age 15–60 years is more or less the same in 2040 as today, cf. Figure 4.11b. This is due to the larger tendency to live as single is matched by a decrease in the number of persons in the age group. The number of couple families is therefore decreasing. However, for persons above 60 years we see a considerable increase in the number of singles. This is mainly due to two things: Partly the above mentioned tendency to be single and partly the so-called demographic ageing, which means that the number of persons above 60 years is expected to be considerably higher in 2040 compared to today. By same reason, there are also considerably more adults over 60 years that lives as couples in 2040 in relation to 2010.

Figure 4.12. Single families' share of the overall number of families, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

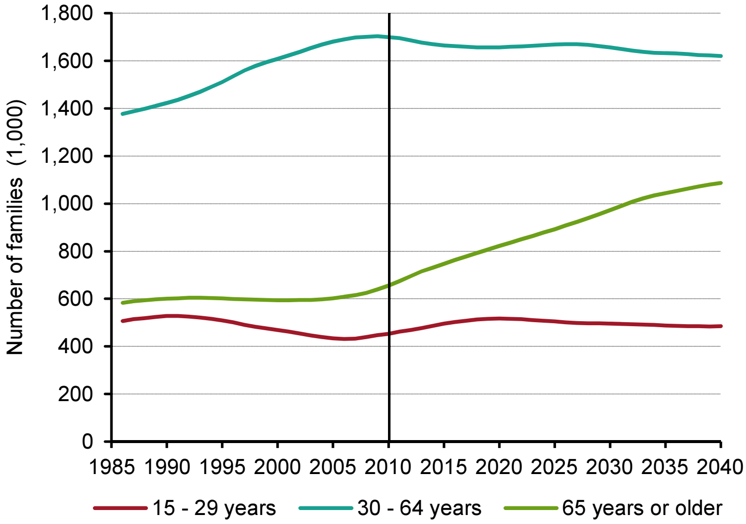
Figure 4.12 shows single families share of the overall number of families in Denmark. The share has increased from 49 pct. to about 53 pct. from 1986 to 2010. In the projection, we expect a continued increase, so singles in 2040 make up about 57 pct. of the overall number of families. The numbers covers considerable regional differences. In the Capital Region of Denmark, we have the country's largest share of single households of 60 pct. in the base year. Besides a general tendency to more people in the Capital Region live as singles, the explanation can also be found in the fact that the population in the region is relatively young and a larger share of young people live as singles. In the other four regions, the share of singles rests on a similar level. Though we see that the Region of Central Denmark is a cut above the other regions in the base year, which is due to a relatively young population in some parts of the region, especially in and around Aarhus. The two regions that historically have had the smallest shares of single families is the Region of North Jutland and the Region of Zealand, due to a relatively older population, as a large share of young people move away from these regions (to study etc.) to move back to the regions later in life as a family.

During the projection period, the share of single families is expected to increase by 5 percentage points. The growth rate is largest in the first part of the forecast, where the share increases at the same rate as in the latest historical years. Over time the increase in the share of single families decrease. In the Capital Region of Denmark, the share of singles increase relatively slightly compared to the increase on national level in the forecast. This is related to a considerable ageing of the population in the Capital Region during the projection period, including also that couple families stays in the region to a greater extent. In the four other regions, the share of singles increase by 4–6 percentage points, a growth rate close to the national average.

Figure 4.13 shows the number of families divided by three age intervals. The first interval contains the 15–29-year-old, which is the age group where you typically will start a family. The second interval consists of the 30–64-year-old, where a fairly constant share of the families is single and couples respectively. The third interval consists of families at age 65 and above, and in this particular interval the share of singles begins to increase as one part of a couple pass away, cf. Figure 4.11.

In Figure 4.13, we see that the growth in the number of families largely is expected to be among the older families, where the average age of the adults is about 65-years-old or above. The number of families of the other two age intervals is fairly constant. This development follows the age composition in the overall population, cf. Figure 4.3.

Figure 4.13. Number of families divided by age intervals, 1986–2040.



Sources: *Statistics Denmark and own calculations.*

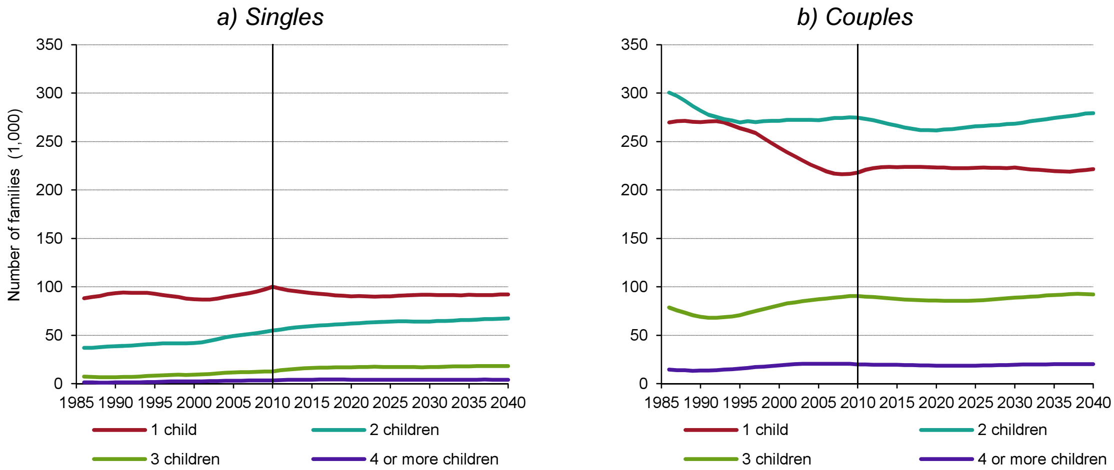
Note: *The vertical line indicates the shift between historical data and forecast.*

4.2.2. Number of children living at home

In the projection, we determine how many children living at home up to an age of 30-years-old is represented in each family. As shown in Figure 4.2, we expect a slight decreasing number of births during the first year of the projection, where after an increasing number of females in the childbearing age increase the number of births to about 70,000 births annually towards 2025. Hereinafter, the number of births is fairly constant, yet slightly decreasing. Children families typically consist of two adults, as 78 pct. of all families with children were a couple in 2010. This share has been slightly decreasing in the past 25 years.

During the period 1986–2010, we see a tendency for an increase in number of single parents. This number increases by roughly 37,000 persons, equal to an increase of 28 pct., cf. Figure 4.14a. It is especially the group of single parents with one child, who has experienced an increase. During the same period, the overall number of singles has increased by 22 pct., so that the number of single parents has increased more than the number of singles in general. In the projection, we expect the number of single parents to be increasing, so the number in 2040 has increased by 11,000 persons compared to 2010, equal to an increase of 6.4 pct. The lower growth rate in the number of single parents in the projection compared to the historical period is due to the number of single parents with one child is decreasing during the projection period. The number of single parents with two children or more is on the other hand continuously increasing.

Figure 4.14. Families divided by number of children, 1986–2040.

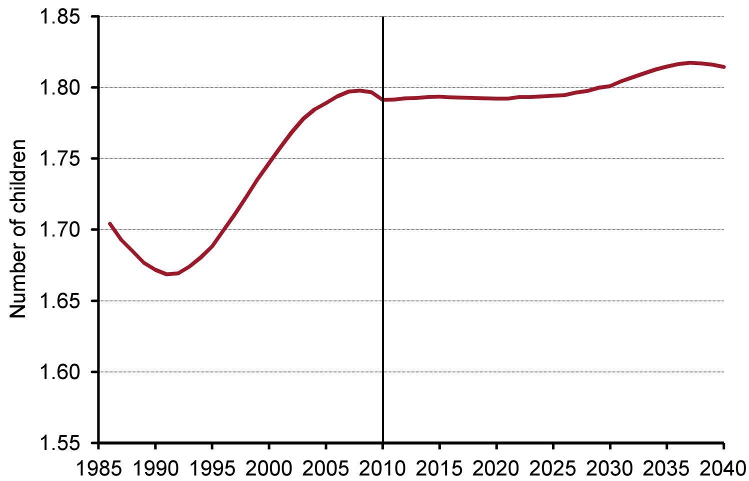


Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

For couple families with two children, we see a decrease in the number of families from the middle of the 1990s, and some years later we see an equivalent decrease in the number of couple families with one child. This is related to the children of the large birth cohorts of the post-war period move away from their parental home. Hereafter the number of couple families with one or two children is fairly constant. From 1995 and onward, we see an increase in the number of families with three children and at the same time a slight increase in the number of families with four children or more. During the projection period, the number of families divided by number of children is fairly constant. This apply for the duration of the projection, that if one couple have children, the most common number of children is two. It is marginally more common to have one child and approximately three times as common as having three children.

Figure 4.15. Average number of children per family, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

Figure 4.15 shows the average number of children per family. At the end of the 1980s, the number is decreasing, as the children of the large births of the post-war period living at home move out of their parental home. From the beginning of the 1900s, this effect is dominated by an increasing number of families with 3 more children, why the average number of children per family is increasing towards 2005. At the same time, the number of families with one child is decreasing, which equally increase the number of children per family. Hereafter, the number of children per families seems to level off on about 1.8 children. During the first 25 years of the projection, this level is maintained, where after we see a smaller increase in the average number of children per family. The increase occurs together with an increase in the number of families with two or three children, cf. Figure 4.14.

4.3. Housing demand

Our model's forecast of the Danish population show that the total population will increase from 5.6 million in 2013 to 6.0 million in 2040. This corresponds to an increase of 7.2 pct. During the same period our forecast shows that the housing demand (number of households) will increase from 2.6 million in 2013 to 2.9 million in 2040, an increase of 13.6 pct. or 0.45 pct. per year. The increase in the housing demand corresponds to a net increase in the housing stock of approximately 11,775 dwellings per year if demand is to be met. With depreciation of existing dwellings at a level of 5,000 per year, this requires the construction of new dwellings to be around 16,775 per year during the next three decades.

As the number of households increases more than the overall population, the number of persons per household decreases from 1.95 pct. in 2013 to 1.88 pct. in 2040, this corresponds to a decrease of 3.5 pct. In other words, it applies that approximately two thirds of the increase in the housing demand during the period until 2040 can be explained by a general increase in the population. The last third can be explained by a changed cohabitation pattern, meaning that an increasing share of the population live in households of only one adult.

Structural changes in the housing demand during the projection period can be explained by three tendencies. Firstly, we expect a considerable ageing, as a larger share of the population will consist of seniors. Secondly, the larger share lives as singles as a consequence of changing cohabitation patterns, and thirdly we expect a larger share of the population to settle around the large urban areas such as the metropolitan area and East Jutland. These three factors indicate that the demand for rented housing is increased in the following decades, and from representing 51.9 pct. of the housing stock in 2010 the share of owner-occupied housing is expected to decrease to 48.0 pct. in 2040.

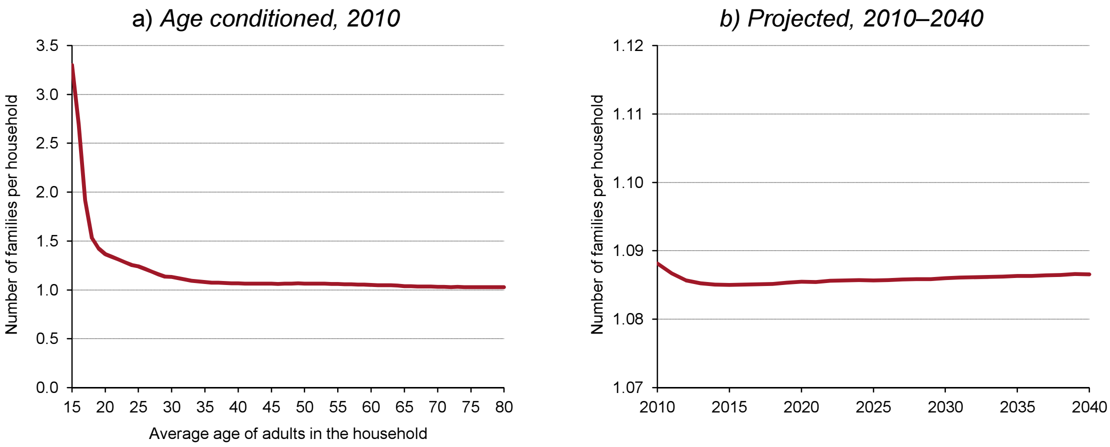
The definition of the applied family type definition makes it possible for more families to live in the same dwelling. For example, it could be two young people of same gender who share a flat while studying. Per definition, this example will count as two independent families (as they are of same gender and do not figure as a registered partnership), but as they live at the same address, they make up one household. So a household consists of all the families living in the same dwelling. The number of households will therefore indicate the number of dwellings, as we disregard persons without a home.

The projected number of families described in chapter 4.2 is therefore converted into a number of households by a scaling factor divided by age, family type, gender, and dwelling characteristics (type, category, province, dwelling size, city size). The scaling factor indicates the average number of families in a household by the given characteristics and is calculated using data from 2010. The scaling factor is kept constant during the projection.

Figure 4.16a shows the average number of families per household in 2010 for each age step between 15 and 80 years. It is most common among young people to live more families in the same household. This will typically be two or more person of the same gender that shares a dwelling. As 15-year-old, only a small share have moved out of their parental home, but those who are live largely in residential institutions, which is why the average number of families per household is relatively high. From age 17, the average number of families per household is lower than two, where after it is gradually decreasing for each age step. From around age 35, each dwelling on average is occupied by close to one family.

Figure 4.16b shows the average number of families per household in the projection. In 2010, 1.008 families on average lived in each dwelling. This level is maintained in the forecast. However, we see quite small variations during the projection period. The variations occur, because the population's age composition, cohabitation pattern and living conditions are relevant to how many families on average live in each dwelling. An ageing population of singles therefore pulls towards a lower average number of families per household, while an increased share of singles in the population pulls towards a higher average number.

Figure 4.16. Number of families per household, age conditioned 2010 and projected 2010–2040.

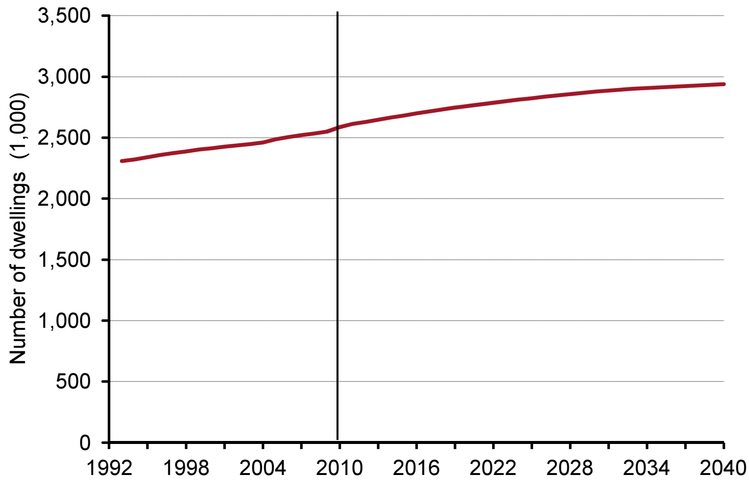


Sources: Statistics Denmark and own calculations.

Figure 4.17 shows the projected development in the number of households and thereby the development of the overall housing demand. Overall, we expect an increasing housing demand the coming 30 years, partly due to a generally growing population as a consequence of longer life expectancy and a positive net immigration from abroad and partly to a changed cohabitation pattern where a larger part of the population lives as singles.

During the period 1993–2010, the number of dwellings in Denmark has increased by between 10,000 and 27,500 annually, and during the historical period the number of dwellings on average has increased by approximately 15,250 dwellings annually. At the beginning of the projection, the housing demand is maintained at the historical level, while the increase rate in the housing demand is decreasing during the projection period. Around year 2040, the housing demand is expected to increase by approximately 5,000 dwellings annually. Overall, the housing demand increases from 2.59 million in 2010 to 2.94 million in 2040, i.e. by approximately 350.000 dwellings equal to an increase of 13.6 pct. During the projection period, the housing demand increase by 11,775 dwellings annually on average.

Figure 4.17. Total number of households in Denmark, 1993–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *The vertical line indicates the shift between historical data and forecast.*

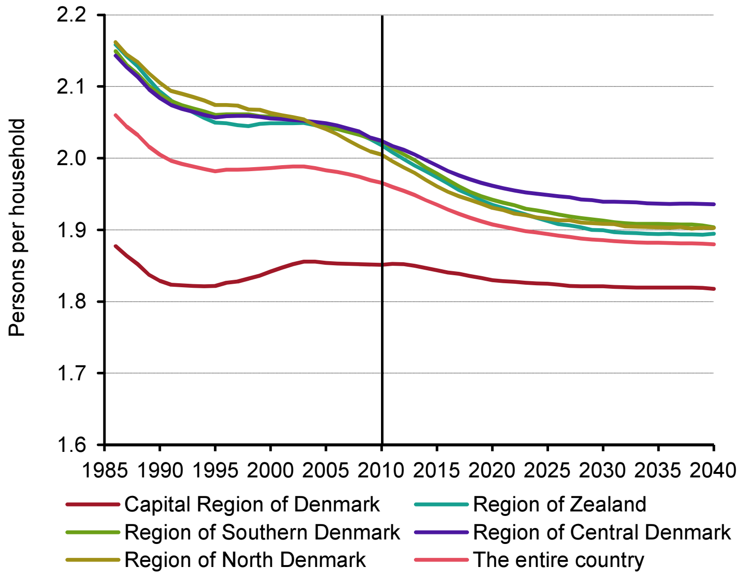
In the period 1986–2010, the number of persons per household including children living at home has decreased considerably. In 1986, more than 2.05 persons occupied one household, a number that has decreased to 1.97 by 2010, cf. Figure 4.18. As described in chapter 4.2, the decreasing number of persons per household is caused primarily by the fact that persons below the pension age to a greater extent live as families of only one person. At the same time, the number of families with children has been decreasing. From the middle of the 1990s to the beginning of the new millennium, the curve level off as the mortality rate for the oldest part of the population begin to decrease, which equalize the effect of the changed cohabitation pattern among the younger part of the population. The last couple of years in the historical period, the number of persons per household decreases again.

The decreasing tendency in the number of persons per household is expected to continue during the projection, as the tendency for a changed household structure and an increasing number of households with only one adult are expected to continue the coming years. At the beginning of the projection, the number of persons per household decrease at the same rate as at the end of the historical period, after which the decreasing tendency decreases over time. The decrease happens as singles represent a larger share of the overall number of families. At the same time, the families with children represent a decreasing share. At the end of the projection period, the number of persons per household is therefore fairly constant at about 1.88 pct.

If you consider the regional development, we see the Capital Region of Denmark clearly stand apart from the national average, as fewer persons live per household in this region than in the rest of the country. This is partly due to that the Capital Region is inhabited by relatively many young people (who live as singles to a greater extent than the rest of the population), and partly because there also among the seniors is a tendency to live as singles. At the end of the 1980s, the development in the number of persons per household in the Capital Region follows the development in the rest of country. From the middle of the 1990s, we see an increasing tendency in the Capital Region, which is due to an increase in the population during this period, and that an increasing share of the population are couples. At the end of the historical period, the number levels off at about 1.84 persons per household. In the four other regions, the development fairly follows the development of the national average, though displaced towards a higher number of persons per household.

In the projection, we expect in all five regions a lower number of persons per household the following years. As for the national average, the decrease is largest at the beginning of the projection, after where the decreasing tendency decreases. In the Capital Region of Denmark and the Region of Central Denmark, the decrease is barely as large as in the other regions, due to a relatively high number of families with children in the large urban areas.

Figure 4.18. Number of persons per household, 1986–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

In the following sections, we are reviewing the projection of the housing demand distributed by dwelling characteristics.

4.3.1. Dwelling type

Dwelling type covers the dwelling's ownership[93]. We distinguish between owner-occupied housing, i.e. dwellings populated by the owner himself, and rented housing which in turn is further

[93] Dwelling type is defined in section 3.1.2. Footnote 54 to 58 on page 47 provides a brief description of each of the five types of dwellings.

subdivided into social housing, cooperative housing, publicly owned rented housing and privately owned rented housing. The most common dwelling type is owner-occupied housing, which in 2010 represent just above half of all dwellings (51.9 pct.), cf. Table 4.1. Then we have social housing and privately owned rented housing that are the most common form of rented housing (and which represent 19.8 pct. and 18.9 pct. respectively of the overall number of dwellings in 2010), followed by cooperative housing (7.7 pct. in 2010) and publicly owned rented housing (1.7 pct. in 2010).

Table 4.1. Number and shares of dwellings by dwelling type, selected years 2000–2040.

	2000	2010	2020	2030	2040
Owner-occupied housing	1,285,673	1,294,306	1,376,973	1,405,218	1,409,679
	53.4 pct.	51.9 pct.	49.9 pct.	48.8 pct.	48.0 pct.
Social housing	474,955	494,333	564,439	594,122	610,664
	19.7 pct.	19.8 pct.	20.4 pct.	20.7 pct.	20.8 pct.
Cooperative housing	156,009	191,885	227,064	249,421	262,755
	6.5 pct.	7.7 pct.	8.2 pct.	8.7 pct.	8.9 pct.
Publicly owned rented housing	43,170	41,721	61,025	74,148	85,915
	1.8 pct.	1.7 pct.	2.2 pct.	2.6 pct.	2.9 pct.
Privately owned rented housing	447,134	471,943	530,896	553,908	569,383
	18.6 pct.	18.9 pct.	19.2 pct.	19.3 pct.	19.4 pct.
Unknown	7,280	66,770	-	-	-
Total	2,414,221	2,560,958	2,760,398	2,876,817	2,938,396

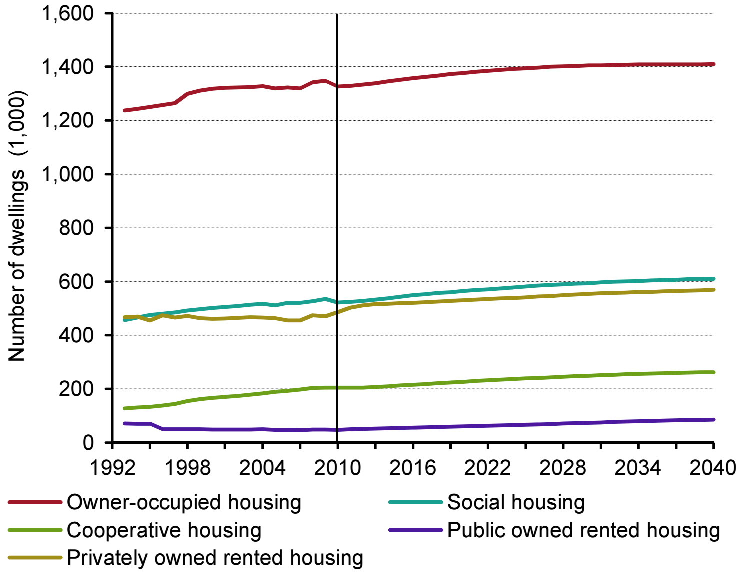
Sources: *Statistics Denmark and own calculations.*

Note: *In the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings of an unknown type in the forecast. The shares indicate each dwelling type's share of the overall number of dwellings without dwellings of an unknown type. Data for year 2000 and 2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Figure 4.19 shows the number of dwellings in Denmark distributed by dwelling type. During the period 1993–2010, the overall number of dwellings in Denmark has increased by about 10 pct. As described above, this is partly due to a generally increasing population and partly to a changed family structure that has increased the number of households.

The number of publicly owned rented housing has decreased during the historical period, while the number of the other four dwelling types has been increasing. The largest percentage-wise increase has happen in the number of cooperative dwellings, which increased by nearly 50 pct. in the period 1993–2005. Hereafter, we only see very few new constructions of cooperative housing, which is why there is only a slight increase in the number of cooperative housing from 2005–2010. The number of cooperative housing has therefore increased by about 60 pct. over the duration of the period 1993–2010, and cooperative housing goes from representing 5.2 pct. of the housing stock in 1993 to 7.7 pct. in 2010. The second largest increase is seen in the number of social housing, which increases by nearly 14 pct. in the period 1993–2010, just only enough to maintain the social housing's share of the overall housing stock. This share increases slightly from 19 pct. in 1993 to about 20 pct. in 2010. During the period 1993–2008, the number of privately owned rented housing has been fairly constant, though with a tendency to a slight decrease, which makes private rented dwellings' share of the overall housing stock decreasing during this period. However, since 2008 the number of privately owned rented houses has increased, which must be presumed to be due to the present crisis. Over the duration of the period 1993–2010, this dwelling type therefore represents a fairly constant share of the overall housing stock. Owner-occupied housing and publicly owned rented housing represents a smaller share of the housing stock in 2010 than in 1993, as both dwelling types have decreased by about 1.5 percentage points.

Figure 4.19. Number of dwellings by type, 1993–2040.



Sources: Statistics Denmark and own calculations.

Note: In the forecast we remove dwellings with one or more unknown characteristic, as they are distributed on known values. There are thus no dwellings of an unknown type in the forecast. The historical data in the figure is therefore scaled to fit the level of the projection in 2010 for each dwelling type. The vertical line indicates the shift between historical data and forecast

In the projection period, we expect a continued increase in the housing demand. The housing demand for all five dwelling types are increased during the projection. The increase is approximately 85,000 dwellings for owner-occupied housing, social housing and privately owned rented housing, which corresponds to an increase of about 2,800 dwellings annually. The increase is largest at the beginning of the projection, after where the demand level off. Compared to the level in 2010, the demand for owner-occupied housing is increased by 6.2 pct., while social housing and privately owned rented housing is increased by 17.0 pct. and 17.1 pct. respectively. The demand for cooperative housing is increased by about 58,000 dwellings during the projection period (28.2 pct.), while publicly owned rented housing is increased by almost 38,000 dwellings (80.2 pct.) This corresponds to an average increase in demand of about 1,900 and 1,300 dwellings annually respectively.

Since the turn of the millennium, owner-occupied housing has represented a decreasing share of the overall housing stock, which mainly can be matched by an increase in the share of cooperative housing. In year 2000, owner-occupied housing represented 53.4 pct. of all dwellings, while this share had decreased to 52.5 pct. by 2007. Through the crisis, the share decreases even further. The tendency to owner-occupied housing representing a smaller share of the overall housing stock is expected to continue for the duration of the projection period. From representing 51.9 pct. of the overall housing stock in 2010, the owner-occupier’s share decreases to 48.0 pct. in 2040. This is matched by a similar increase in the share of rented housing, where the largest relative increase is seen in publicly owned rented housing and cooperative housing, which both increase by 1.2 percentage points. Hereafter follows social housing (1.0 percentage points) and privately owned rented housing (0.5 percentage points).

That owner-occupied housing is expected to represent a smaller share of the housing stock in the forecast follows three tendencies. Firstly, we expect a considerable ageing, so a larger share of the population will consist of seniors. Secondly, a larger share lives as singles due to a changed cohabitation pattern, and thirdly we expect a larger share of the population to settle around the large urban such as Central and Surrounding Copenhagen and East Jutland (which includes Aarhus). All three conditions points toward an increasing demand for rented housing over owner-occupied housing. The ageing of the population especially increase the demand for publicly owned rented housing and social housing, as these types is constituted by senior housing to some extent. The changed cohabitation pattern and the centralization around the large urban areas increase the demand for cooperative housing and privately owned rented housing. Because these dwelling types are common among single people (especially right after a break up of couples), and the dwelling types are also relatively more common in the large cities.

In the projection, we see a relatively large increase in the demand for cooperative housing. This relates to the fact that the household's choice of dwelling is estimated during the period 2000–2010. In relation to the whole period 2000–2010, we have seen a relatively large influx in cooperative housing. However, from about 2005 there is only constructed very few new cooperatives. If this tendency is permanent, you could argue that the model overestimates the demand for cooperative housing. Looking forward we can see new cooperative housing, if existing privately owned rented housing is transformed into cooperative housing.

Figure 4.20 shows the share of the overall number of households living in owner-occupied housing for each age step between 15 and 100 years. At the youngest age steps, below one third lives in owner-occupied housing, as you as a young person typically wants a low housing cost (for example, if you are studying) and a large mobility, which an owner-occupied house cannot fulfil. After completed education, and as more persons begin to start a family, the share of owner-occupied housing in the housing stock increase towards the age step 35–40 years. Hereafter we see a fairly constant share living in owner-occupied houses forward until immediately after the pension age of 65 years, where a share move out of their owner-occupied house in order to move into another type of dwelling that better suits their needs as seniors and without children.

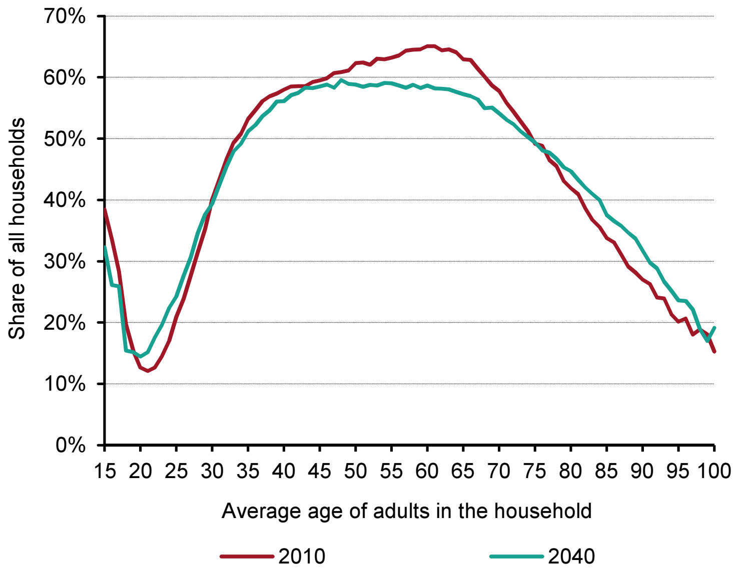
In the projection, we expect a lower share of the 50–75-year-old to live in owner-occupied housing, due to a historical tendency where a decreasing share of the population live in owner-occupied housing. This tendency is expected to continue in the projection, as we see no tendency for a net influx to owner-occupied housing after people turn 40–45-year-old. So the relatively low share that lives in owner-occupied housing as 40–45-year-old in 2010 is displaced throughout the projection, so it also includes the seniors. So, 66.2 pct. of the 45-year-old families in 1995 lived in owner-occupied housing, while this applies to 64.3 pct. of the 60-year-old families in 2010. For this "cohort" of families, the share that lives in owner-occupied housing has largely been unchanged during this 15-year period. In 2010, the share of 45-year-old that lives in owner-occupied housing has decreased to 58.9 pct.[94]. As we subsequently do not see any net influx to owner-occupied housing after the age of 45, the share living in owner-occupied housing in the forecast will also be lower. In 2025, about 60 pct. of the 60-year-old families will still be living in owner-occupied housing.

Furthermore, in the forecast we expect that families will be living in owner-occupied housing until they reach a higher age. So the share among families of 75-years or older living in owner-

[94] The share of the 45-year-old that lives in owner-occupied housing is relatively low in 2010. You could argue that this is caused by the present crisis, which can have kept some people from moving into an owner-occupied house. However, throughout the period 1993–2010 we see a tendency to a decreasing share of the 45-year-old living in owner-occupied housing, so the low share in 2010 is not assessed only to be an effect of the financial crisis.

occupied housing is larger in 2040 than in 2010, due to a longer life expectancy in the population, which postpone the time where the families move out of the their owner-occupied house by a higher age.

Figure 4.20. Age conditioned share of households in owner-occupied housing, 2010 and 2040.



Sources: Statistics Denmark and own calculations.

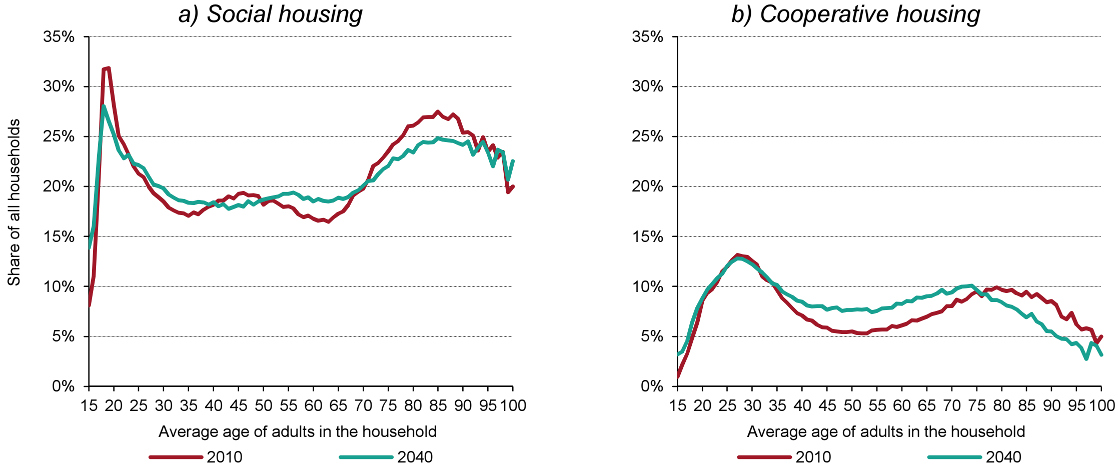
Figure 4.21 shows the share of the overall number of households of between 15 and 100 years that live in social or cooperative housing. A relatively high share of up to 30 pct. of the 18–25-year-old lives in social housing, due to a share of the social housing are outright youth housing, including student housing. Hereafter the share is decreasing to about age 35, where a fairly constant share of the households of about 20 pct. lives in social housing. From the present retirement age at age 65, the share begins to increase as the households move out of their owner-occupied house into a smaller dwelling without maintenance obligations. A share of the social housing is outright nursing homes and senior housing, which also increase the influx among the oldest age steps.

In the projection, we expect an increase in the share of the 50–70-year-old families that lives in social housing in 2040, due to a decrease in the share living in owner-occupied housing in this age group and that a part of these instead move into social housing. In 2040, we expect a more constant share of the 30–65-year-old to live in social housing. For persons above 75-years, we see a smaller share of the households living in social housing in 2040 than in 2010, due to an increasing life expectancy during the projection, which cause the seniors to live longer together as couples and therefore occupy their owner-occupied house for a longer period of time.

The share of the overall number of household living in cooperative housing is increasing to the end of their 20s. Hereafter, the share is decreasing until age 45 as you start a family and move away from the large urban areas, where cooperative housing typically are located, to move into a detached house instead. A detached house is typically owner-occupied housing. As seniors, the share who live in cooperative housing is increasing, as the households move out of their detached houses and into smaller dwellings instead, such as terraced houses and apartments, whereof a larger share is cooperative housing.

In the projection, we expect an increasing share of household to live in cooperative housing as 35–75-year-old. This relates to a decreasing share living in owner-occupied housing at this age interval. As it would have been the case in the historical period, a part of these seek to move into a cooperative housing instead. In year 2000, about 4.3 pct. of the 45–55-year-old lived in cooperative housing. This share increase to about 5.5 pct. in 2010, and in the projection the increasing tendency continues so that 7.5 pct. of the overall number of households of 45–55-years lives in cooperative housing in 2040.

Figure 4.21. Age conditioned share of households living in social or cooperative housing, 2010 and 2040.



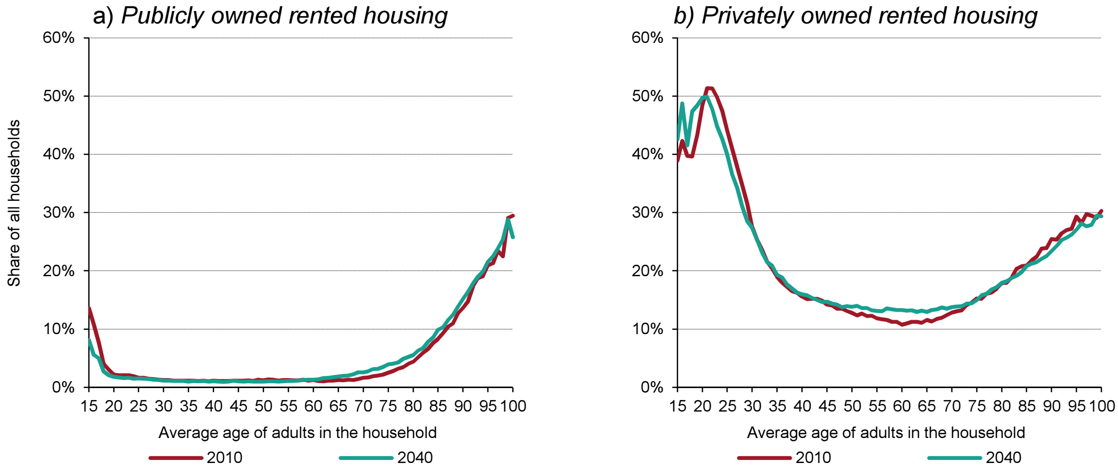
Sources: Statistics Denmark and own calculations.

Figure 4.22 shows how large a share of the overall number of households that lives in publicly owned or privately owned rented housing. Publicly owned rented housing is dwellings owned by the municipality, region or state and then rented out to the citizens. These dwellings are typically targeted at certain groups of individuals, e.g. young people, disabled individuals or the elderly. Privately owned rented housing is dwellings owned by private persons, corporations or independent institutions and are inhabited by someone else than the owner. This includes e.g. dwellings in traditional rental properties and sublet owner-occupied housing.

Among the 15–17-year-old that have moved away from their parental home, a relatively large share lives in publicly owned rented housing in the shape of youth housing. Hereafter, that share is decreasing, and from around age 30 on to age 65, approximately 1 pct. lives in publicly owned rented housing. This includes dwellings for disabled people, mentally vulnerable, disadvantaged adults and homeless people. From age 65 and onward, the share increases as more people move into nursing or senior homes. At each age step, we expect the share of the overall number of household living in publicly owned rented housing to remain roughly the same during the projection, cf. Figure 4.22a. In the projection it is assumed that a family's housing behaviour is fairly constant for a given age. The housing choice will therefore not be affected by the increase of the life expectancy in Denmark. You could argue that an increasing life expectancy may result in the need for assistance to the elderly could be postponed, so the need for example for nursing and senior homes is put of until later in life. By that also argue that the model overestimates the need for publicly owned rented housing, as a large share of these are nursing and senior homes.

Many young people live in privately owned rented housing, due to this type of dwelling usually is a cheap way of living, as a large part of them also comprise of student housing. Furthermore, it is easy to vacate privately owned rented housing, which confirms the high mobility among young people. The share that lives in privately owned rented housing reaches its apex at the beginning of the 20s; where well over half of all households live in this dwelling type. Hereafter the share is decreasing towards age 65 as more people start families and move to a larger dwelling of a more permanent character. From age 65 and onward, the share living in privately owned rented housing increases again, due to among other things an influx to nursing and senior homes not owned by the public sector (but for instance pension funds). The influx can also be caused by a wish for a smaller dwelling without maintenance. For each age step, we expect the share of the overall number of households living in a privately owned rented housing to maintain the same level throughout the projection, cf. Figure 4.22b.

Figure 4.22. Age conditioned share of households living in publicly owned or privately owned rented housing, 2010 and 2040.



Sources: Statistics Denmark and own calculations.

4.3.2. Dwelling category

The use of dwellings is determined by the dwelling's category[95]. Dwellings are basically used for permanent residence, business purposes or as a holiday home. In 2010, more than 98 pct. of the populated stock is registered as permanent residences. Dwelling category is determined by nine categories.

Detached houses, multi-dwelling houses and terraced houses (including linked houses and double houses) are the most dominant dwelling categories. Detached houses are detached one-family houses that represent 40.7 pct. of the housing stock in 2010, cf. Table 4.2. Multi-dwelling houses represent approximately 38 pct. and are characterized by a horizontal separation between the housing units within a building. Then we have the terraced houses etc. (14.5 pct.) that are characterized by a horizontal separation. Farmhouses make up barely 4.3 pct. The rest of the permanent dwellings are distributed on student housing, residential institutions and other residential buildings. Residential institutions include nursing and senior homes as well as orphanages and juvenile homes among others. The rest of the populated stock consists of properties for commercial use, holiday houses and dwellings of an unspecified kind.

Figure 4.23 shows the number of dwellings distributed by the four most common categories of dwellings. These four categories together make up approximately 97 pct. of the overall populated housing stock. The most common categories is detached houses and multi-dwelling houses (together 78.6 pct. of the overall number of dwellings in 2010), and these categories have made up an almost constant share of the overall housing stock in the historical period. Terraced houses represent 14.5 pct. of all dwellings in 2010. It is an increase of almost 2 percentage points

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[95] Dwelling category is defined in section 3.1.2. Footnote 58 to 65 on page 49 provides a brief description of each of the nine dwelling categories.

compared to 1993. In the historical period, a similar decrease in the share of farmhouses has happened. Farmhouses represent 4.3 pct. of the housing stock in 2010.

Table 4.2. Number and share of dwellings distributed by category, selected years 2000–2040.

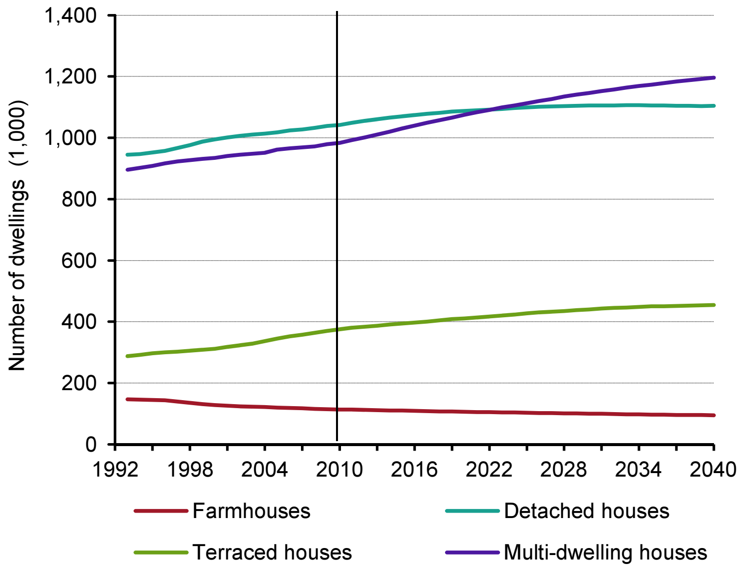
	2000	2010	2020	2030	2040
Farmhouses	124,615	110,450	106,339	100,448	94,958
	5.2 pct.	4.3 pct.	3.9 pct.	3.5 pct.	3.2 pct.
Detached houses	989,585	1,036,086	1,087,855	1,105,405	1,104,343
	41.0 pct.	40.7 pct.	39.4 pct.	38.4 pct.	37.6 pct.
Terraced houses	306,205	368,289	410,729	440,221	454,760
	12.7 pct.	14.5 pct.	14.9 pct.	15.3 pct.	15.5 pct.
Multi-dwelling houses	918,682	966,357	1,075,164	1,146,129	1,196,435
	38.1 pct.	37.9 pct.	38.9 pct.	39.8 pct.	40.7 pct.
Student housing	28,689	29,816	33,260	33,693	33,868
	1.2 pct.	1.2 pct.	1.2 pct.	1.2 pct.	1.2 pct.
Other residential buildings	7,481	6,199	8,593	8,885	9,113
	0.3 pct.	0.2 pct.	0.3 pct.	0.3 pct.	0.3 pct.
Properties for commercial use	6,896	6,485	8,176	8,398	8,515
	0.3 pct.	0.3 pct.	0.3 pct.	0.3 pct.	0.3 pct.
Residential institutions	16,091	7,704	9,266	10,845	12,948
	0.7 pct.	0.3 pct.	0.3 pct.	0.4 pct.	0.4 pct.
Holiday houses	15,745	17,004	21,015	22,793	23,454
	0.7 pct.	0.7 pct.	0.8 pct.	0.8 pct.	0.8 pct.
Unknown	232	12,568	-	-	-
Total	2,414,221	2,560,958	2,760,398	2,876,817	2,938,396

Sources: *Statistics Denmark and own calculations.*

Note: *In the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings of an unknown category in the forecast. The shares indicate each dwelling category's share of the overall number of dwellings without dwellings of an unknown category. Data for year 2000 and 2010 are historical data, while data for year 2020 and the following years are in the forecast.*

In the projection period, we still expect detached houses and multi-dwelling houses to make up approximately 78 pct. of the overall number of dwellings. However, the relative relation between these two categories is displaced in the projection as the demand for detached houses is expected to remain fairly constant at around 110,000 dwellings, while we see an increasing demand for multi-dwelling houses during all of the projection. Therefore the share of detached houses in the housing stock decreases from 40.7 pct. in 2010 to 37.6 pct. in 2040. During the same period, the share of multi-dwelling houses increases from 37.9 pct. to 40.7 pct. The reason is an expected population-wise centralization around the large urban areas, where a larger part of the housing stock is multi-dwelling houses rather than detached houses. Of same reason, we see the share of terraced houses make up a continued increase in the housing stock during the projection period. The share of terraced houses of the overall number of dwellings increases from 14.5 pct. in 2010 to 15.5 pct. in 2040. The increase mainly takes place in the first part of the projection, after where the demand for terraced houses level off to end up being fairly constant by the end of the projection. As in the historical period, the demand for farmhouses is expected to be slightly decreasing the coming years. The share of farmhouses decrease from 4.3 pct. of the housing stock in 2010 to 3.2 pct. in 2040, due to an expectation of a smaller population in the rural areas.

Figure 4.23. Number of dwellings by category (selected categories), 1993–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *In the forecast we remove dwellings with one or more unknown characteristic, as they are distributed on known values. There are thus no dwellings of an unknown category in the forecast. The historical data in the figure is therefore scaled to fit the level of the projection in 2010 for each dwelling category. The vertical line indicates the shift between historical data and forecast.*

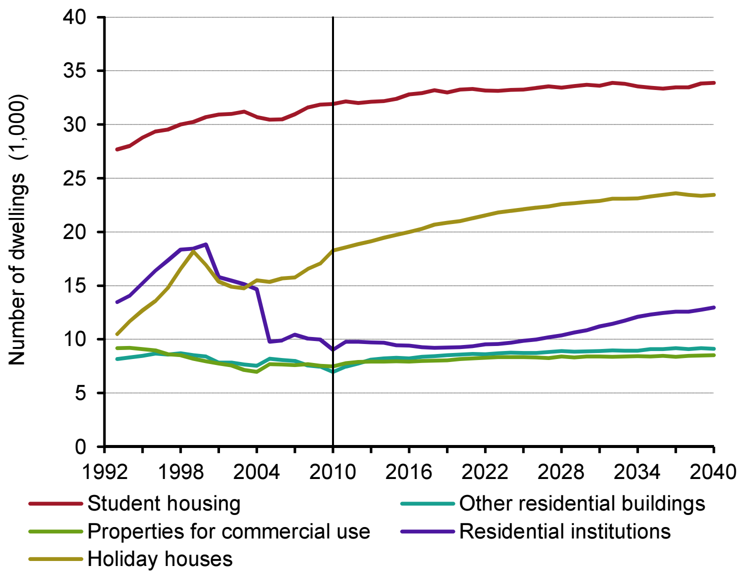
Figure 4.24 shows the number of dwellings distributed by the remaining five categories that together make up approximately 3 pct. of the overall housing stock. The most common of these is student housing, which number has been increasing over the last 20 years. This is explained by more people attend a higher education, which leads to an increase in the demand for student housing. In the first ten years of the projection, we expect a continued increase in the demand for student housing, as the number of students on the higher educations also continue to increase during this period, cf. Figure 4.6. After 2020, we expect a relatively constant number of students on the higher educations, which is why the demand for student housing levels off at about 33,000 dwellings. Throughout the duration of the projection period, student housing make up 1.2 pct. of the overall housing stock.

The number of holiday houses used as permanent residence is increasing during the 1990s to about 18,000 immediately before the turn of the millennium. Because of this increase, the rules for permanent residence in holiday homes are tightened in 1999, after where the number decreases to approximately 14,000 dwellings in 2004. Then the number becomes fairly constant just to increase considerably in the latest historical years. In the projection, we expect a continued increase in the number of permanent residents in holiday houses, which increases to about 21,000 dwellings in 2020, after where the number just is slightly increasing. The increase in the demand for holiday houses follows the general increase in the housing demand.

Residential institutions include nursing and senior homes as well as orphanages and juvenile homes. The number of households with permanent residence at a residential institution was increasing during the 1990s and reached its apex around the turn of the millennium. After, the number has been decreasing towards 2010, where the residential institutions made up about 10,000 dwellings. In the projection, we expect a slightly increasing demand for dwellings in residential institutions towards 2020. Hereafter, the demand begins to increase, and after 2025 we see an increase of about 200 dwellings annually. The increase in demand occurs among the older part of the population and shall mainly be credited to a general ageing in the population, as the number of seniors increase considerably, cf. Figure 4.13. In the projection we assume, that to the extent a person's housing behaviour depends on age, this behaviour will not be affected by an increase in life expectancy in society. We do not consider that a longer life can mean several years of good health (so-called healthy aging), so this has not been included, as an increase in life expectancy can cause the need for helping the elderly to be postponed, then also postponing the need for senior housing to a later point in life. Therefore, you can argue that the model overestimates the need for senior housing.

The number of households the reside in properties for commercial use or other permanent dwellings is under 8,500 households for each form of dwelling category. Historically, the number is fairly constant, though with a tendency to be slightly decreasing. In the projection, the number is also constant; though with a tendency to a slight increase as the overall number of households increase during the projection period.

Figure 4.24. Number of dwellings by category (selected categories), 1993–2040.



Sources: *Statistics Denmark and own calculations.*

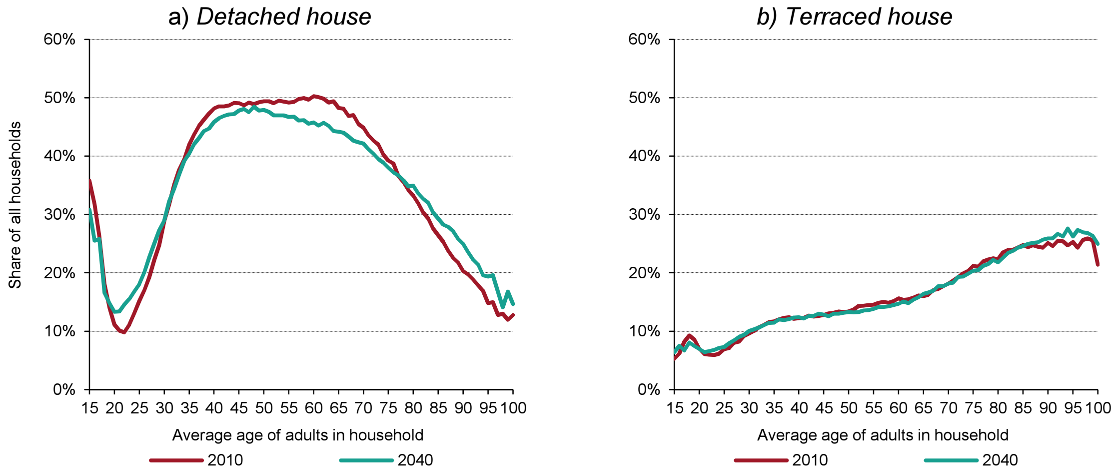
Note: *In the forecast we remove dwellings with one or more unknown characteristic, as they are distributed on known values. There are thus no dwellings of an unknown category in the forecast. The historical data in the figure is therefore scaled to fit the level of the projection in 2010 for each dwelling category. The vertical line indicates the shift between historical data and forecast.*

Figure 4.25a shows the share of the overall number of households that live in a detached house for each age step between 15 and 100 years. At the youngest age steps, a proportionate high share of over 30 pct. lives in detached houses. The number of independent families at these age steps is relatively low. But if out of those families, a relatively large share still live with their parents in a detached house (you form an independent family, if you give birth to a child). At the beginning of their 20s, only about 10 pct. lives in a detached house. Hereafter the share is increasing to about 50 pct. by the end of their 30s. This increase happens as you find a permanent partner and start a family. From the end of their 30s to about the retirement age, a relatively constant share lives in detached houses. Hereafter the share is decreasing, when children living at home have moved away, and you to a larger extent want a smaller dwelling.

In 2040, we expect a lower share of the 45–75-year-old to live in a detached house, due to an expectation in the projection of a changed cohabitation pattern, where more people live as singles, and that single people live in detached houses to a lesser extent than couples. Furthermore in the projection, we expect an increase in the influx to the larger urban areas, where detached houses are slightly represented. However among persons of age 75 and above, the share living in detached houses increase in 2040 compared to in 2010. This is due to the longer life expectancy in the population, which postpones the point when families move out of their detached house to a higher age. Generally, the share living in detached houses is very similar to the share living in owner-occupied housing, cf. Figure 4.20, as there is a great resemblance between the two categories.

If you consider the share living in terraced houses, this is steadily increasing throughout life, cf. Figure 4.25b. At the oldest age steps, about 25 pct. of the overall number of households lives in a terraced house. At each age step, the share of the overall number of households living in terraced houses is not expected to change considerably in the projection.

Figure 4.25. Age conditioned share of households living in detached or terraced houses, 2010 and 2040.

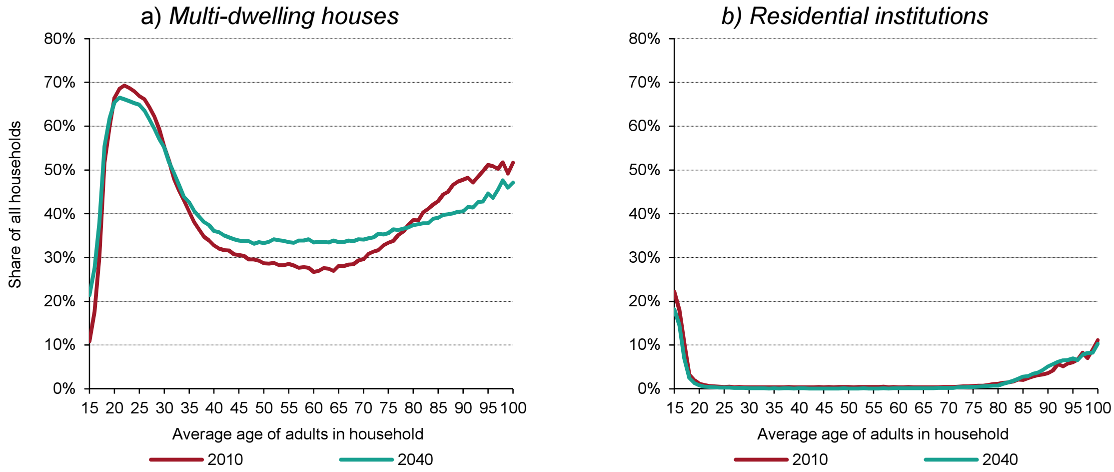


Sources: Statistics Denmark and own calculations.

The share of household living in multi-dwelling houses is high throughout the 20s, cf. Figure 4.26a, hereafter, the share is heavily decreasing towards the end of the 30s, where after the decreasing tendency gradually seizes. From age 65, an increasing share of the household again lives in multi-dwelling houses. In 2040, we expect an increasing share of the 35–75-year-old to live in multi-dwelling houses, due to a larger share of the population lives in the urban areas. As the households in 2040 remain in their detached houses for a longer period than in 2010, the share living in multi-dwelling houses among persons age 75 and above decreases in 2040.

Among the young people under age 18 that have moved away from home, a relatively high share of about 20 pct. live in an residential institution, cf. Figure 4.26b. Hereafter the share is under 1 pct. until about age 80, where it increases again to about 10 pct. for all household of age 100. In the projection, we do not expect any changes in the share of households living in residential institutions. As described above, this can cause an overestimation of the number of residential institutions.

Figure 4.26. Age conditioned share of households living in multi-dwelling houses or residential institutions, 2010 and 2040.



Sources: Statistics Denmark and own calculations.

4.3.3. Dwelling size

The size of dwellings is determined by living area in square meters distributed by five intervals. About half of the populated housing stock consists of dwelling of at least 100 m^2. However, the most common dwelling size is 60–99 m^2, as about 37 pct. of the overall housing stock have this size in 2010, cf. Table 4.3.

Table 4.3. Number and shares of dwellings by size, selected years 2000–2040.

	2000	2010	2020	2030	2040
0–59 m^2	325,446	306,310	342,511	363,270	378,384
	13.5 pct.	12.0 pct.	12.4 pct.	12.6 pct.	12.9 pct.
60–99 m^2	907,643	944,311	1,030,054	1,092,541	1,133,220
	37.6 pct.	37.1 pct.	37.3 pct.	38.0 pct.	38.6 pct.
100–119 m^2	330,913	346,089	383,238	404,207	414,723
	13.7 pct.	13.6 pct.	13.9 pct.	14.1 pct.	14.1 pct.
120–159 m^2	512,611	544,375	574,033	583,955	582,892
	21.2 pct.	21.4 pct.	20.8 pct.	20.3 pct.	19.8 pct.
160 m^2 and above	337,608	407,516	430,562	432,844	429,176
	14.0 pct.	16.0 pct.	15.6 pct.	15.0 pct.	14.6 pct.
Unknown	0	12,357	-	-	-
Total	2,414,221	2,560,958	2,760,398	2,876,817	2,938,396

Sources: Statistics Denmark and own calculations.

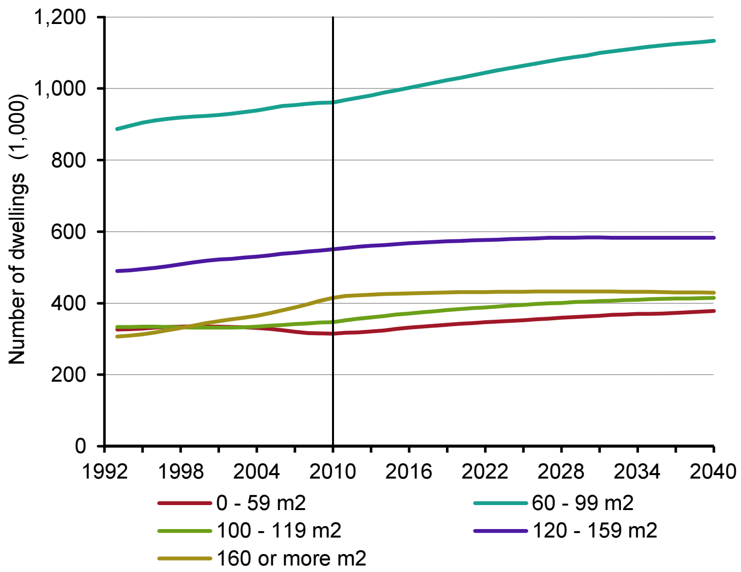
Note: In the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings of an unknown size in the forecast. The shares indicate each dwelling size's share of the overall number of dwellings without dwellings of an unknown size. Data for year 2000 and 2010 are historical data, while data for year 2020 and the following years are in the forecast.

Figure 4.27 shows the number of dwellings distributed by dwelling size. During the period, we see a tendency for an increase the average dwelling size. The share of dwelling of less than 120 m^2 is then reduced from making up 66.0 pct. of the overall number of dwellings in 1993 to 62.7 pct. in 2010. Dwellings of 59 m^2 will typically be smaller apartments, while dwellings of 100–119 m^2

typically will be smaller houses. In the historical period, the number of dwellings in both these intervals has been fairly constant, while the number of dwellings in the other three intervals has increased. This also indicates that the household have moved to larger apartments and houses in the period 1993–2010.

In the projection, we expect an increase in the housing demand for dwellings smaller than 120 m^2 in the long run. These dwelling represent 62.7 pct. of the housing stock in 2010, while their share is expected to increase to 65.6 in 2040. That the demand for smaller dwellings increases the coming years, are mainly caused by three factors: (i) In the projection, the number of singles increase, while the number of couples and families with children are fairly constant, (ii) the housing demand is increase especially for the senior part of the population, and (iii) we expect an increased influx towards the larger urban areas. These three factors all increase the demand for the smaller dwellings that are well suited for single people and seniors and are located in the larger cities

Figure 4.27. Number of dwellings distributed by dwelling size, 1993–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *In the forecast we remove dwellings with one or more unknown characteristic, as they are distributed on known values. There are thus no dwellings of an unknown size in the forecast. The historical data in the figure is therefore scaled to fit the level of the projection in 2010 for each dwelling size. The vertical line indicates the shift between historical data and forecast.*

Historically, the number of dwellings smaller than 60 m^2 has made up a slightly decreasing share of the overall housing stock. In the projection, this share is kept largely constant, which results in an increase of the number of dwellings in the period 2010–2040 of approximately 63,500 dwellings, as the housing demand generally is increasing in the period. The share of dwellings of 60–99 m^2 is constant at the beginning of the projection, but from around 2015 dwellings of 60–99 m^2 make up an increasing share of the overall stock. The share increases from representing 37.1 pct. in 2010 to 38.6 pct. in 2040. The last ten years, dwellings of 100–119 m^2 have made up a largely constant share of 13.6 pct. of the overall housing stock. This share is slightly increasing during the projection period to 14.1 pct. in 2040, which corresponds to the share of dwelling size in the beginning of the 1990s. Also dwellings of 120–159 m^2 have made up a constant share of 21.4 pct. of the overall housing stock during the last ten years. In the projection, the share is decreasing to 19.8 pct. in 2040. Dwellings of more than 160 m^2 have made up an increasing share of the housing stock during the historical period. In the projection, the increase rate is lower than in the historical period, and the number of dwellings of more than 160 m^2 stabilize as the number of families with children becomes constant. As the overall number of dwellings at the same time is increasing, then the largest dwellings represent a decreasing share of the housing stock during the projection period. So dwellings of more than 160 m^2 make up 16.0 pct. of all dwellings in 2010, and the share is expected to decrease to 14.6 pct. in 2040.

4.3.4. The location of the dwellings

The location of the dwellings obviously depends of the national population development, which is described in section 4.1.3. So to begin with let us highlight the main results of that section, where the population in number of person is described. In the coming years, we expect a continued influx to the Capital Region of Denmark and the Region of Central Denmark in particular. In the period 2010–2040, we expect the overall Danish population to increase by about 470,000 persons, equal to an increase of 8.5 pct., of which about 465,000 persons (99 pct.) is expected to settle in the Capital Region of Denmark or the Region of Central Denmark. In the projection period, the population in the Capital Region increases by about 335,000 persons (20.0 pct.), while the population in Region of Central Denmark increases by about 130,000 persons (10.2 pct.). In the same period, the population in the Region of Southern Denmark and the Region of Zealand is slightly increasing, as these increase by 17,000 persons (1.4 pct.) and 2,500 persons (0.3 pct.). In the Region of North Jutland, the population is expected to decrease by 16,000 persons the coming 30 years, which corresponds to a decrease of 2.7 pct. Towards 2040, we therefore expect an increased centralization around the large urban areas.

Table 4.4. Number and shares of dwellings distributed by region of residence, selected years 2000–2040.

	2000	2010	2020	2030	2040
Capital Region of Denmark	776,143	803,568	883,579	946,698	996,340
	32.1 pct.	31.4 pct.	32.0 pct.	32.9 pct.	33.9 pct.
Region of Zealand	345,204	371,046	393,807	402,844	402,668
	14.3 pct.	14.5 pct.	14.3 pct.	14.0 pct.	13.7 pct.
Region of Southern Denmark	519,035	551,285	585,128	598,035	599,113
	21.5 pct.	21.5 pct.	21.2 pct.	20.8 pct.	20.4 pct.
Region of Central Denmark	517,332	565,600	617,804	646,986	661,369
	21.4 pct.	22.1 pct.	22.4 pct.	22.5 pct.	22.5 pct.
Region of North Denmark	256,507	269,459	280,080	282,254	278,905
	10.6 pct.	10.5 pct.	10.1 pct.	9.8 pct.	9.5 pct.
Total	2,414,221	2,560,958	2,760,398	2,876,817	2,938,396

Sources: *Statistics Denmark and own calculations.*

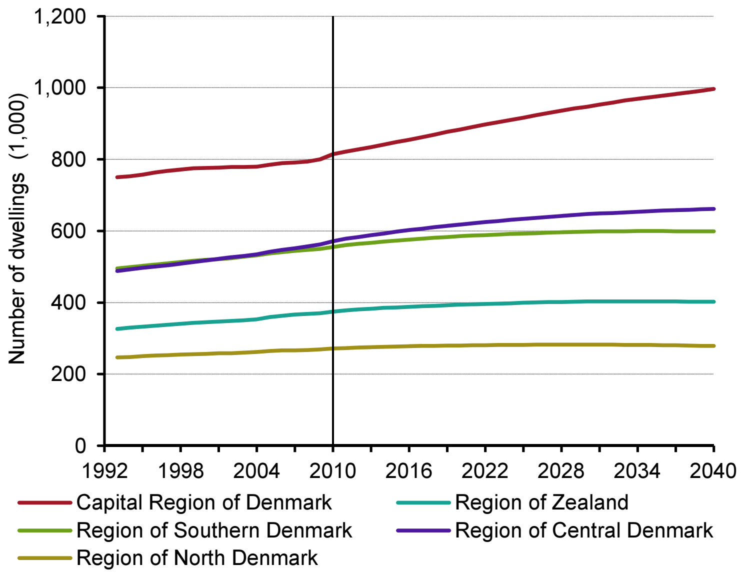
Note: *The shares indicate the location of each dwelling as a share of the overall number of dwellings. Data for year 2000 and 2010 are historical data, while data for 2020 and the following years is projection.*

The increasing population in the Capital Region of Denmark and the Region of Central Denmark leads to a considerable increase in the housing demand in the two regions. Overall, the housing demand is expected to increase by approximately 350,000 dwellings in the period 2010–2040, of which roughly 270,000 of the dwellings (77.5 pct.) is presumed to be located in the Capital Region and the Region of Central Denmark, cf. Table 4.4. The rest of the increase is expected to occur in the Region of Southern Denmark and the Region of Zealand, while the housing demand in the Region of North Jutland only is slightly decreasing. The share of the housing stock in the

Capital Region and the Region of Central Denmark increases from 53.5 pct. in 2010 to 56.4 pct. in 2040.

Figure 4.28 shows the number of dwellings in each region. As described above, we expect the largest growth in the housing demand to take place in the Capital Region of Denmark and the Region of Central Denmark, where we expect the number of demanded dwellings to increase by about 180,000 (22.4 pct.) and 90,000 dwellings (15.7 pct.) respectively in the period 2010–2040. This corresponds to an increase of approximately 6,000 and 3,000 dwellings annually. The housing demand increase a little more than the population growth in the regions indicates which is due to the changed family structure, where a larger share lives as singles. In the Region of Southern Denmark and the Region of Zealand, the housing demand increases by 43,500 (7.9 pct.) and 28,000 (7.4 pct.) dwellings respectively, which annually corresponds to 1,500 and 1,000 dwellings respectively in the projection period. In the Region of North Denmark, where we expect a slightly decreasing population, the housing demand slightly increases due to the changed cohabitation pattern. In 2040, we expect a demand of nearly 7,500 more dwellings (2.8 pct.) in the Region of North Denmark compared to 2010, which corresponds to an increase of approximately 250 dwellings annually during the 30-year period.

Figure 4.28. Number of dwellings by region of residence, 1993–2040.



Sources: Statistics Denmark and own calculations.

Note: The vertical line indicates the shift between historical data and forecast.

City size is determined by five categories that define the size of the urban area in the region, where dwellings are located. The categories include the metropolitan area and areas outside Copenhagen of at least 50,000 inhabitants, 10,000–49,000 inhabitants, 1,000–9,999 inhabitants and fewer than 1,000 inhabitants. The majority of dwellings are located in the metropolitan area, where 23.0 pct. of the housing stock is situated, cf. Table 4.5, then we have dwellings located in cities by 10,000–49,999 and 1,000–9,999 inhabitants. These city sizes represent 22.0 pct. and 21.2 pct. respectively of the overall number of dwellings in 2010. In addition, 18.1 pct. of the dwellings are located in rural areas or villages with less than 1,000 inhabitants, while the remaining 15.7 pct. are located in cities with more than 50,000 inhabitants outside the metropolitan area.

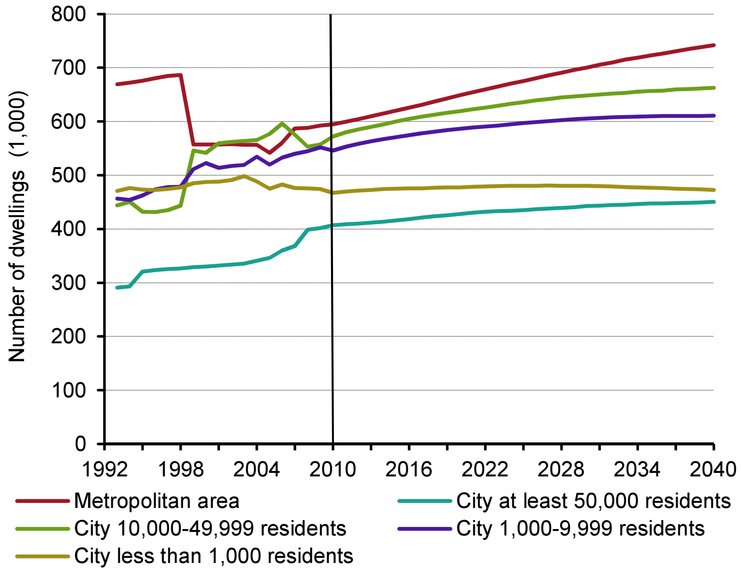
Table 4.5. Number and shares of dwellings distributed by city size for location of dwelling, selected years 2000–2040.

	2000	2010	2020	2030	2040
Metropolitan area	551,998 22.9 pct.	588,790 23.0 pct.	648,723 23.5 pct.	700,319 24.3 pct.	741,967 25.3 pct.
City with at least 50,000 residents	326,802 13.5 pct.	403,166 15.7 pct.	428,093 15.5 pct.	442,627 15.4 pct.	450,459 15.3 pct.
City with 10,000–49,999 residents	532,606 22.1 pct.	562,714 22.0 pct.	619,411 22.4 pct.	648,255 22.5 pct.	662,725 22.6 pct.
City with 1,000–9,999 residents	520,439 21.6 pct.	543,857 21.2 pct.	586,606 21.3 pct.	605,347 21.0 pct.	610,600 20.8 pct.
City with less than 1,000 residents	482,376 20.0 pct.	462,430 18.1 pct.	477,564 17.3 pct.	480,269 16.7 pct.	472,644 16.1 pct.
Total	2,414,221	2,560,958	2,760,398	2,876,817	2,938,396

Sources: *Statistics Denmark and own calculations.*

Note: *In the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings of an unknown city size in the forecast. The shares indicate each city size's share of the overall number of dwellings without dwellings with an unknown city size. Data for year 2000 and 2010 are historical data, while data for year 2020 and the following years are in the forecast. Areas with more than 49,999 inhabitants is situated outside the metropolitan area per definition.*

Figure 4.29. Number of dwellings distributed by city size for location of dwelling, 1993–2040.



Sources: *Own calculations based on register data from Statistics Denmark.*

Note: *In the forecast we remove dwellings with one or more unknown characteristic, as they are distributed on known values. There are thus no dwellings of an unknown city size in the forecast. The historical data in the figure is therefore scaled to fit the level of the projection in 2010 for each city size. The vertical line indicates the shift between historical data and forecast. Areas with more than 49,999 inhabitants is situated outside the metropolitan area per definition.*

Figure 4.29 shows the number of dwellings distributed by size of the urban areas, where the dwelling is located. The number of dwellings in the metropolitan area is expected to increase by about 150,000 towards 2040, equal to an increase of 24.8 pct. This corresponds roughly to the increase of the overall population in the Capital Region of Denmark. However, there is not full conformity between the metropolitan area and the Capital Region, like changes in the household structure also has an effect.

The number of dwellings located in cities with 10,000–49,999 inhabitants increase by about 90,000 dwellings during the period 2010–2040, equal to 15.8 pct. This is especially due to an increase in the number of dwellings in the medium sized cities in Jutland, as the increase occurs in the regions of Jutland, particularly in South and East Jutland. The number of dwellings in the smaller cities with 1,000–9,999 inhabitants increases by about 65,000 (11.8 pct.) during the projection period. The smallest growth is expected in the larger cities with more than 50,000 inhabitants (by an increase of about 45,000 dwellings, 10.6 pct.) and in the rural areas and the smallest villages (by an increase of about 5,000 dwellings, 1.1 pct.).

4.4. Housing investments

In chapter 4.3, the housing demand is forecasted until year 2040. The forecast indicates the need for the overall housing stock measured in number of dwellings and in residential square meters. The result of the projection is that the housing demand is expected to increase from 2.59 million dwellings in 2010 to 2.94 million in 2040. The increase in the housing demand leads to an increase in the demand for residential square meters, as we expect to increase within the same period from 290 million m^2 in 2010 to 322 million m^2 in 2040. In this chapter, the need for housing investments is valued towards 2040 based on the overall demand for residential square meters.

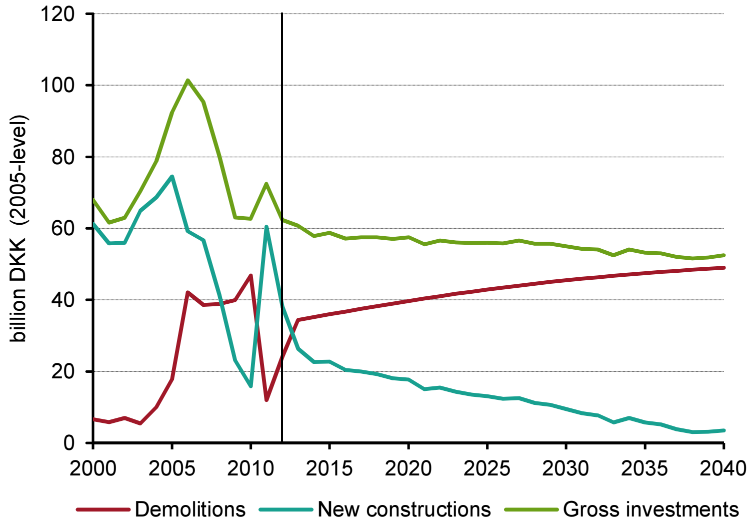
The need for residential construction depends partly of the existing housing stock that with time will be demolished, and partly in the need for more new dwellings as the demand increases due to the demographic, family and socioeconomic development. The need for new dwellings is forecasted in chapter 4.3.

The need to replace demolished dwellings depends on the age of the housing stock and arises, when the dwellings pass their expected life expectancy. Then the building is demolished, and the housing stock reduced accordingly. The dwellings' expected life expectancy depends on the construction date of the building and follows Statistic Denmark's life expectancy for the calculation of fixed capital, in our calculations. Is the housing stock to be maintained, it requires an investment matching the number of dwellings demolished each year.

The costs for housing constructions are established as the value of constructed square meters measured by the average construction costs used by Statistics Denmark to measure the stock of residential capital for dwellings constructed after 1940. During the projection period, the construction costs are maintained at the level of 2012. The total gross housing investments including both net and replacement investments are expected to be 60 billion kroners with a small decline towards 2040. However, the relatively constant level covers up a large increase in the need for replacement constructions as a consequence of the buildings from 1935–1950 that were of poorer quality than the previous years are to be replaced, cf. Figure 4.30**Fejl! Henvisningskilde ikke fundet.**.

In these calculations, we have not considered housing investments as a consequence of a possible need of the households for an improvement of the dwelling compared to the present standard. However, this can also pull in the opposite direction, if the households reduce their demand for the standard of their future dwelling.

Figure 4.30. Housing investments, fixed prices, 2000–2040.



Sources: *Statistics Denmark and own calculations.*

Note: *The gross investments indicate the values of the necessary housing investments that partly secure the stock's present size and partly meet any new needs. New construction indicates the value of new dwellings to meet the demand of new households. Demolished dwellings indicate the value of dwellings that in a given year is to be replaced due to obsolescence of the dwelling. The costs are fixed. Historically, demolished dwellings are determined as changes in the gross stock that not are investments. New constructions are historically determined as the residual between demolished dwellings and the observed gross investments. The vertical line indicates the shift between historical data and forecast.*

Section 4.4.1 describes age distribution of the housing stock in 2012, obtained from an extract of the building and housing register (BBR). Section 4.4.2 describes Statistics Denmark's measurement of the value of the housing stock in Denmark, while section 4.4.3 on this basis, calculates the need to replace dilapidated buildings in the future, and the forecast of the overall housing need from chapter 4.3 calculates the total demand for housing investments up to 2040.

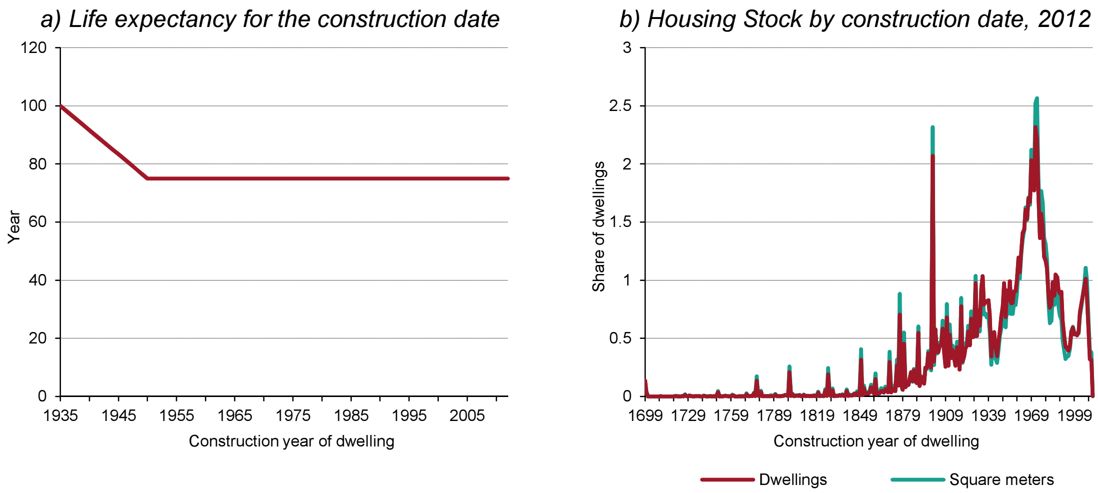
4.4.1. Housing stock in 2012

To determine the number of dwellings and square meters of dwellings that in the future will have to be replaced due to obsolescence, requires the age distribution of the housing stock. This is retrieved from the building and housing register (BBR) early 2012.

The life expectancy of a dwelling is assumed to follow the lifespan of Statistics Denmark uses in the calculation of fixed capital in the national accounts. For dwellings built before 1935, the lifespan is set to 100 years, while dwellings built after 1950 are expected to live for 75 years, cf. Figure 4.31a. The life of dwellings constructed between 1935 and 1950 is assumed to be linearly reduced. Life expectancy is determined on the basis of an estimation of Danish historical figures that are best in the PIM calculation[96] restores the population trends in relation to the observed development based on building and housing register.

More than 10 pct. of the current stock was built before 1900, while newer buildings mainly date from the period 1960–1980, which today represent for over a third of the housing stock, cf. Figure 4.31b. In 2012, over one third of the housing stock has been built before 1940 and are therefore set at a lower price per square meter than newer buildings, cf. below. The part of the housing stock that is expected to be replaced by 2040, account for almost 38 pct. of the population in 2012, which makes up 44 pct. of the buildings set at a lower price per square meter.

Figure 4.31. Housing stock, 2012.



Sources: *Statistics Denmark (the building and housing register, BBR) and own calculations.*

Note: *The life expectancy is the number of years from the time of construction of the dwelling is expected to be demolished. Homes built before 1935 are assumed to have a lifespan of 100 years.*

4.4.2. Housing stock since 1966

Each year, Statistics Denmark calculates the development in the value of the housing stock, categorised under fixed capital. The value is calculated as both a gross and net stock. The gross stock express square meter per dwelling measured by replacement costs for new dwellings, while the net stock express the gross stock adjusted for technical and economic depreciation.

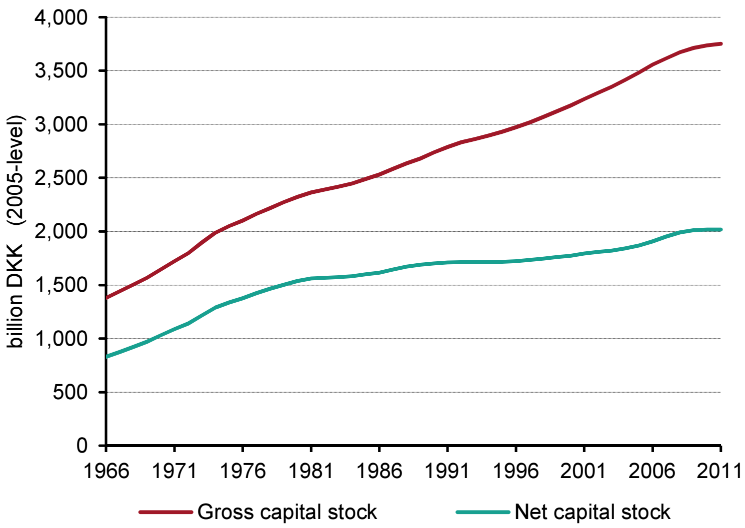
The gross housing stock express to some extent the need for housing benefit, while the net housing stock reflects the market value of dwellings in the free trade and good conduct. Much of the difference is that the economic depreciation takes into account the present value of dwelling benefits decreases, when the remaining life expectancy is reduced. However, this economic depreciation does not necessarily worsen the dwelling’s annual capacity to satisfy the household's housing needs. Part of the difference is also, however, that the net housing stock includes an increased need for maintenance costs in order to maintain quality of the dwelling, such as insulation, roof leakage, etc. However, this only affects the time profile of the investments. It is estimated that the gross housing stock indicates the household’s needs for housing benefit and thus establishes the housing investments with regard to replace dilapidated dwellings.

[96] Perpetual Inventory Method (PIM) is a methodology that, based on either very long addition and withdrawal statements or an initial inventory and addition and withdrawal inventories, establishes development in the portfolio as initial inventory plus additions minus withdrawals.

The calculation of the gross housing stock is based on the building and housing register (BBR) of housing stocks after 1988, while the housing stock prior to 1988 are based on a PIM approach. There are used two types of prices per square meter, one for buildings from before 1940 and one of the buildings after 1940. The difference is due to the buildings from before 1940 has several installation deficiencies, such as lack of shower, toilet and/or central than newer buildings. The correction of all installations for buildings constructed before 1940 account for just 13 pct. compared to newer construction. The measurement of the housing stock in fixed prices uses the construction cost index.

The gross housing stock has more than doubled since 1966, while the net housing stock has not had the same explosive increase, cf. Figure 4.32. The lower growth rate in the net housing stock compared to the gross housing stock is partly due to the lower quality of new buildings, and their shorter life expectancy for dwellings built after 1950.

Figure 4.32. The value of the housing stock, fixed prices, 1966–2011.



Source: *Statistics Denmark*

Note: *The gross stock indicates the housing stock measured by replacement costs for new homes. The net stock indicates the gross stock of dwellings adjusted by the impairment, which happens due to technical and economic depreciation.*

4.4.3. Estimation of housing investments

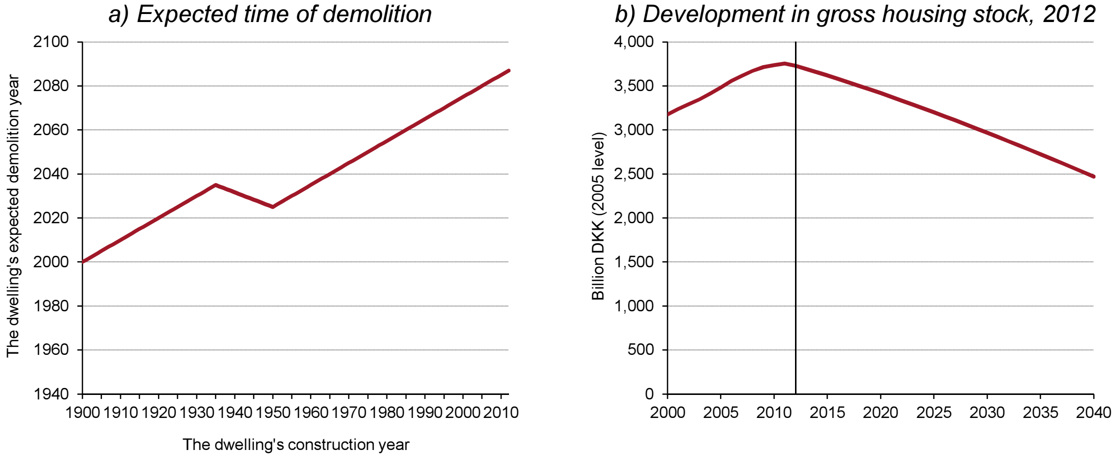
Based on the age distribution of the 2012 housing stock, the assumption of life expectancy and the value of dwellings measured by replacement cost in 2012, the value of the annual demolition of homes are calculated towards 2040. The housing investments, which will replace the demolished dwellings in a given year, are given by the value of the residential square meters being demolished. The number of square meters of housing, which is expected to be demolished within a given year, is assumed to follow a type of distributions used by Statistics Denmark for commercial buildings.

This demolition value represents the required investment costs in housing to replace dwellings that are so worn that they are no longer adequate to meet the general housing needs. In other words, they express the need for housing investments to maintain the gross stock of housing at a given level.

It is noted that the dwellings that are predominantly expected to be demolished in the period 2012–2040, are buildings that were built in the period up to 1966, cf. Figure 4.33a. However, it is assumed that the housing stock built before 1900 through urban renewal and total renovation has brought the housing stock in a state that provides a life expectancy similar to a new home in 2012. This is supported by the demolitions of these dwellings have historically been extremely limited.

The need to build new dwellings and not only maintain the existing housing stock, is described in chapter 4.3, and this will require the gross housing stock to increase accordingly. The value of newly constructed dwellings shall be the average price per square meter of dwellings constructed after 1940 in the 2012 housing stock.

Figure 4.33. Demolition time and expected development in the housing stock.

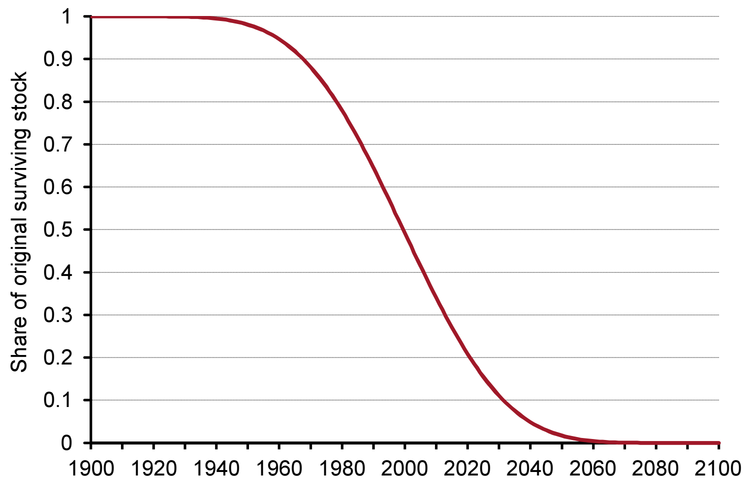


Sources: *Statistics Denmark and own calculations.*

Note: *Expected time of demolition is the year of construction plus life expectancy for a given generation of buildings constructed a given year, if there have not been any renovations. The gross housing stock of the 2012-stock express the development in the value of the generations of buildings constructed before 2013 in residential square meters. The vertical line in the right figure indicates the shift between historical data and forecast.*

The demolition is assumed to follow a distribution that reflects the fact that the housing stock in a given year is composed of a variety of dwellings of varying quality. This means that the dwellings listed in any given year will be demolished in different years, but life expectancy is the same. In this calculation, we have chosen to use a so-called Winfrey S3 distribution. Figure 4.34 shows an example of a survival curve for a dwelling built in 1900. The life expectancy of such dwelling is provided for 100 years.

Figure 4.34. Survival function for dwellings constructed in year 1900.



Source: *Own calculations.*

Note: *The survival function indicates the share of a generation of dwellings that has not been torn down in a given year.*

The use of a survival function to determine the number of demolished residential square meters means that the need for housing investments is smoothened on a longer time interval compared to an assumption that the entire generation of dwellings is demolished at the same time.

5. Conclusion

In the long term, the development of the housing stock will be determined by the demand for housing. In the short term, the housing demand is determined by a number of economic factors such as disposable income, the price for existing housing, the interest rate, etc. In the longer term, it will to a larger extend be the demographic development that determine the housing demand. The population size, age composition, cohabitation patterns, educational background, etc. is largely determining the long-run demand for housing.

For the purpose, we have developed an individual-based microsimulation model that projects the demand for housing based on the regional demographic developments. The result is a forecast of the number of households in Denmark, i.e. we have a forecast of the number of single people and couples as well as the number of children living at home belonging to each household. A household’s choice of housing is described by movements between dwellings, estimated on the basis of the housing behaviour in the period 2000–2010. The model projects the housing demand until 2040.

The results of the forecast points towards a continued positive population growth in the coming decades. The total Danish population is expected to grow from 5.6 million people in 2012 to 6.0 million in 2040. During the projection period, the population’s age composition changes, so a significantly larger proportion of the population consists of seniors, due to the projection include a continuation of the historical tendency towards an increasing lifespan. As the large birth cohorts of the post-war period at the same time reaches the present retirement age, the population growth almost exclusively seen to be in the age interval 65 years and above.

The projection is also indicating that a continued population centralization around the major urban areas in the period until 2040 will occur, particularly in the Capital Region and East Jutland (which includes Aarhus). On average, the population in the Capital Region is expected to grow by about 11,000 persons annually until 2040. In East Jutland, the population growth is almost half as large (approximately 4,300 persons per year), while in the regions Zealand, South Denmark and North Denmark we only expect a modest change in population size in the coming decades.

The increasing population leads to an increase in the number of households, thus also an increase in the housing demand. At the same time, we expect a larger share of the population living as singles. This is a continuation of a historical tendency that is often justified by increasing welfare, which makes the single life possible. Overall, the increasing population and the changing pattern of cohabitation increase the number of households from 2.59 million in 2012 to 2.94 million in 2040.

The housing demand is defined as the number of dwellings necessary if there is to be one dwelling for each household. This is often called the potential housing demand. The result of the projection is that the housing demand will increase at the same rate as the number of households, i.e. by approximately 350,000 dwellings in the period 2010–2040. This corresponds to a net increase in the housing stock of 11,775 dwellings per year over the next 30 years. In comparison, the housing demand has increased by between 10,000 and 27,000 dwellings annually in the period 1993–2010, where the average increase has been 15,250 dwellings. With an annual attrition of approximately 5,000 dwellings, this increase in housing demand means, that housing construction on average must be about 16,775 dwellings per year in the coming decades to meet the increase in the housing demand.

A generally growing population explains about two-thirds of the increased housing demand in the period until 2040. The remaining third can be explained by a changed cohabitation patterns, which means that an increasing share of the population lives in households with only one adult.

During the projection period, changes in demand for certain types of dwellings can mainly explained by three factors. Firstly, a significant ageing is expected, so a greater share of the total population will consist of older people or seniors. Secondly, a greater share lives as single due to changed cohabitation pattern. Thirdly, a larger share of the population is expected reside around the major urban areas such as the metropolitan area and East Jutland. These three factors all point to an increased demand for rented housing in the coming decades. From a level of 48.1 pct. of the housing stock in 2010, the share of rented housing is expected to increase to 52.0 pct. in 2040. This results in a corresponding decrease in the share of owner-occupied housing.

The aging of the population increases mainly the demand for publicly owned rented housing and social housing, as these substantially consists of nursing and senior homes. The changed cohabitation pattern and centralization around the major urban areas increases particularly the demand for privately owned rented housing and cooperative housing. This is due to these two types of housing are overrepresented among single people and in urban areas.

The results of the projection also points towards an increase, albeit modest, in the demand for detached houses in the period up to 2040. This is because the population growth is primarily expected to be among people aged 65 years or more, where the households typically begin to vacate their detached houses in favour of smaller dwelling types. At the same time, we see in influx toward the main urban areas, where detached housing is relatively rare. It is therefore believed that detached houses will represent a decreasing proportion of the overall housing stock in the future. The share of detached houses of the housing stock is expected to decrease from

40.3 pct. in 2010 to 37.3 pct. in 2040. It is matched by an increase in multi-dwelling houses and terraced houses' proportion of the overall number of dwellings.

The projection of the housing demand is created with the newly developed, individual-based microsimulation model SMILE. The projection model is very detailed, but there are still some inaccuracies in the method chosen.

In the projection, it is assumed that in the extent a person's moving pattern or housing choice depends on his or her age, this behaviour will not be affected by that lifespan of society is assumed to increase over the projection period. Therefore we do not take into account that longer life expectancy may mean several years of good health. If so, it may affect the households' housing choices so that, for example, moving to senior housing put off until later in life.

In the projection, we use moving patterns and housing choices that are estimated on the basis of the housing behaviour in the period 2000–2010. The period is relatively long to check for cyclical fluctuations in the behaviour. However, this has the disadvantage that you, to the extent that housing behaviour has changed within the historical period, are likely to continue tendencies in the projection, which are no longer valid.

To achieve a better modelling of a person's life-cycle, it would be obvious to extend the microsimulation model with income, i.e. including a modelling of each person's earned income and transfers from the government sector in each of the model periods. This model would be used for a detailed life-cycle analysis. This could for example be different education groups' total income over a lifetime or calculating future pension payments, which largely depends on each person's savings until retirement age. Several empirical studies show that a household's disposable income is crucial for the development of the housing consumption. The expansion of income necessitates, among other things, a better modelling of labour market affiliation and establishing a tax and benefit system.

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Appendix A3.4

Table A.1. List of variables used in decision trees dealing with household characteristics.

Characteristics	Input variable	Value set	Description
Age			**Age at the end of the year.**
personal level	age	1 year age levels	The person's age.
family level	$famage$	1 year age levels	For families consisting of couples, age is calculated as the average of the ages of the two adults. For single families, we use the age of the adult person. The variable is ordered with the ranking: 0, 1, 2, …
Family type and gender			**Family type in terms of couples and singles where singles are subdivided by gender.**
personal level	$gender$	{female, male}	The person's gender.
family level	$famtype\_gender$	{couple, single female, single male}	Families are characterized as couples or single. Singles are subdivided by gender. The variable is non-ordered.
Educational background			**Highest completed education.**
personal level	edu_comp	6 categories	We use an aggregation containing 6 education categories. The highest completed education is characterized by long-cycle higher education (LV), medium-cycle higher education (MV), short-cycle higher education (KV), vocational education (EF), upper secondary education (GY) and elementary school (GS). The variable is ordered with the ranking: LV, MV, KV, EF, GY and GS.
family level	$famedu\_comp1$ $famedu\_comp2$	6 categories for singles and 10 categories for couples	For families consisting of singles, we use the variable edu_comp. For families consisting of couples, we use ten categories described by two variables: - $famedu\_comp1$: Specifies the highest completed education of the adult who have the highest educational level. It contains six categories and is sorted in the above order. - $famedu\_comp2$: Specifies whether the adults in a couple have different categories of highest completed education. It is a binary variable with the value 0 for couples where both adults have the same or similar education category[1]. The value 1 occurs when they have different categories.
Origin			**Origin relative to origin type and country of origin.**
personal level	$origin$	5 categories	Characterizing origin as Danish (DK), immigrant from a Western (IW) or non-Western country (IX) and descendant from a Western (DW) or non-Western country (DX). The variable is non-ordered.
family level	$fam\_origin1$ $fam\_origin2$ $fam\_origin3$ $fam\_origin4$	5 categories for singles and 15 categories for couples	For families consisting of singles, we use the variable $origin$. For families consisting of couples, we use 15 categories described by four variables: - $fam\_origin1$: Specifies the origin of the first adult with three values (Dane, immigrant or descendant) and is not ordered. - $fam\_origin3$: Specifies whether the first person's country of origin is Western or non-Western. - $fam\_origin2$: Specifies the origin of the second adult with three values (Dane, immigrant or descendant) and is not ordered. - $fam\_origin4$: Specifies whether the first person's country of origin is Western or non-Western.
Labour market status			**Labour market status in relation to socio-economic status.**
personal level	$statusLab$	2 categories	Characterizing in binary form whether a person are in the labour force (as employed or unemployed) or are outside the workforce (undergoing education, temporary outside, retired etc.).
family level	$famstatusLab1$ $famstatusLab2$	2 categories for singles and 3 categories for couples	For families consisting of singles, we use the variable $statusLab$. For families consisting of couples, we use 3 categories described by two variables: - $famstatusLab1$: Indicates whether at least one of the adults participating in the labour force (value 1) or whether both are outside (the value 0). - $famstatusLab2$: Specifies whether one of the adults participating in the labour force, while the other stands outside (value 1) or whether they are both a part of the labour force or both standing outside (the value 0).
Children in the household			**Indication of whether there are children in the household.**
personal level	$d\_children$	{children, no children}	Characterizing in binary form whether a household containing children.
family level	$d\_children$	{children, no children}	Characterizing in binary form whether a household containing children.

Sources: Own creation on the basis of Statistics Denmark.

Note 1: By "similar" education categories we mean two categories for the ordered variable, located next to each other. This applies, for example, the categories KV and MV.

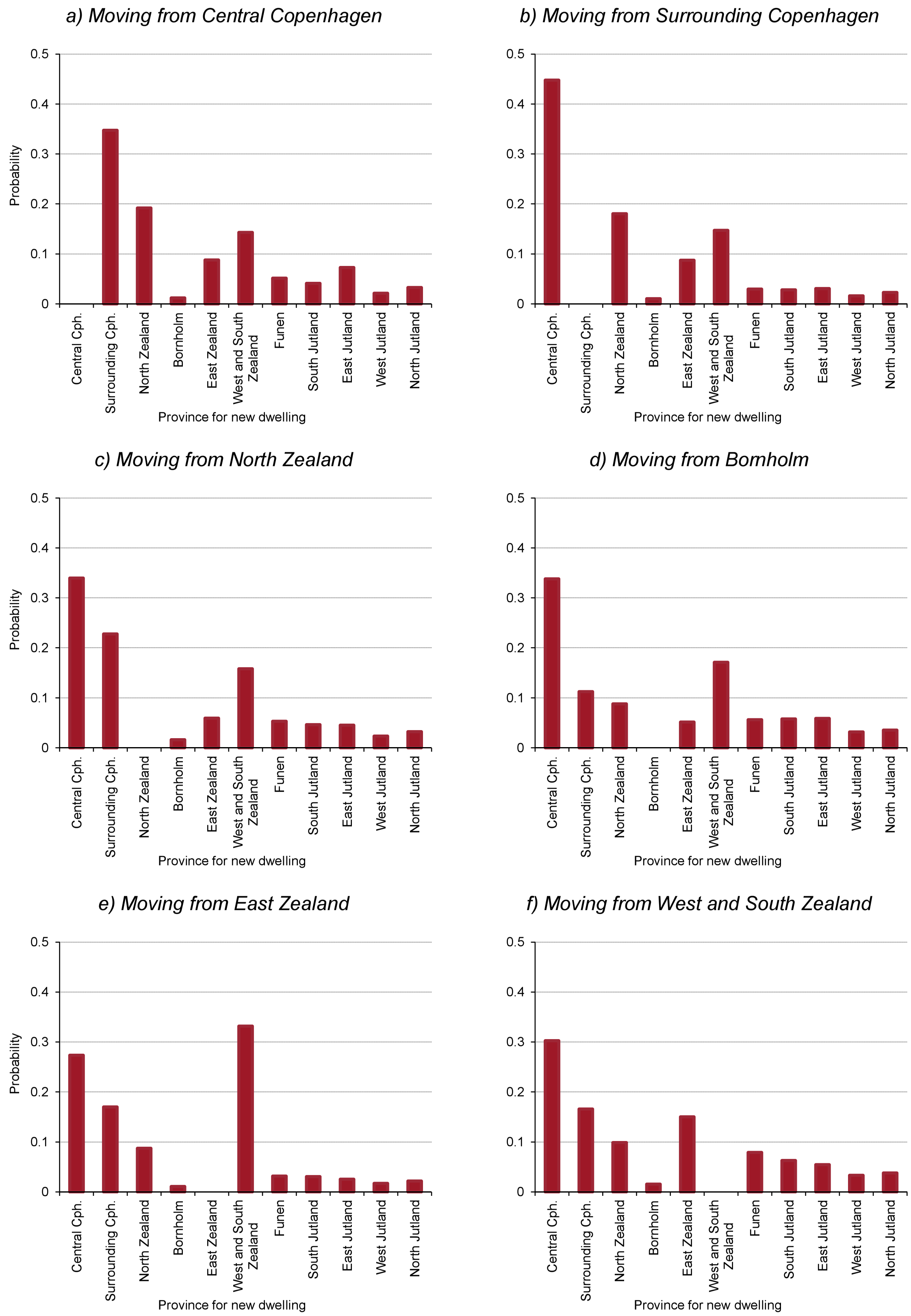
Table A.2. List of variables used in decision trees dealing with dwelling characteristics.

Characteristics	Input variable:	Value set	Description
Province			**Province for the location of the dwelling.**
	$dwPro$	11 categories	Specifies the location of the dwelling in a province corresponding to a subdivision of the five Danish regions. Provinces include Central Copenhagen, Surrounding Copenhagen, North Zealand, Bornholm, East Zealand, West and South Zealand, Funen, South Jutland, East Jutland, West Jutland, and North Jutland. The variable is non-ordered.
Type			**Ownership and rental status of the dwelling.**
	$dwType$	5 categories	Dwelling type is defined by the owner-rental relationship. Dwelling types include owner-occupied housing, social housing, cooperative housing, public owned rented housing, and privately owned rented housing. The variable is non-ordered.
Category			**Physical use of the dwelling**
	$dwCat$	9 categories	Specifies the type of the dwelling from its primary use. The categories include farmhouses, detached houses, terraced houses (including linked houses and double houses), multi-dwelling houses, student housing, other residential buildings, properties for commercial use, residential institutions, and holiday houses. The variable is non-ordered.
Size			**Size of the dwelling measured with living space.**
	$dwSize$	8 categories	Specifies the dwellings total living area according to the BBR-registration (field 311). The intervals include 0-39 m^2, 40-59 m^2, 60-79 m^2, 80-99 m^2, 100-119 m^2, 120-159 m^2, 160-199 m^2 and at least 200 m^2. The variable is ordered.
Town size			**Town size for the location of the dwelling.**
	$dwCity$	5 categories	Specifies the size of the urban area where the dwelling is located. The categories include the metropolitan area as well as areas outside the metropolitan area measured by town size in the following four intervals; city with at least 50,000 residents, city with 10,000–49,999 residents, city with 1,000–9,999 residents, and city with less than 1,000 residents. The variable is ordered.
Age			**The dwellings age in the form of decade for commissioning.**
	$dwAge$	12 categories	Specifies the decade of the dwellings actual commissioning. The intervals include the years up to 1900, 1900-09, 1910-19, …, 1990-99 and 2000 or later. The variable is ordered.

Sources: *Own creation on the basis of Statistics Denmark.*

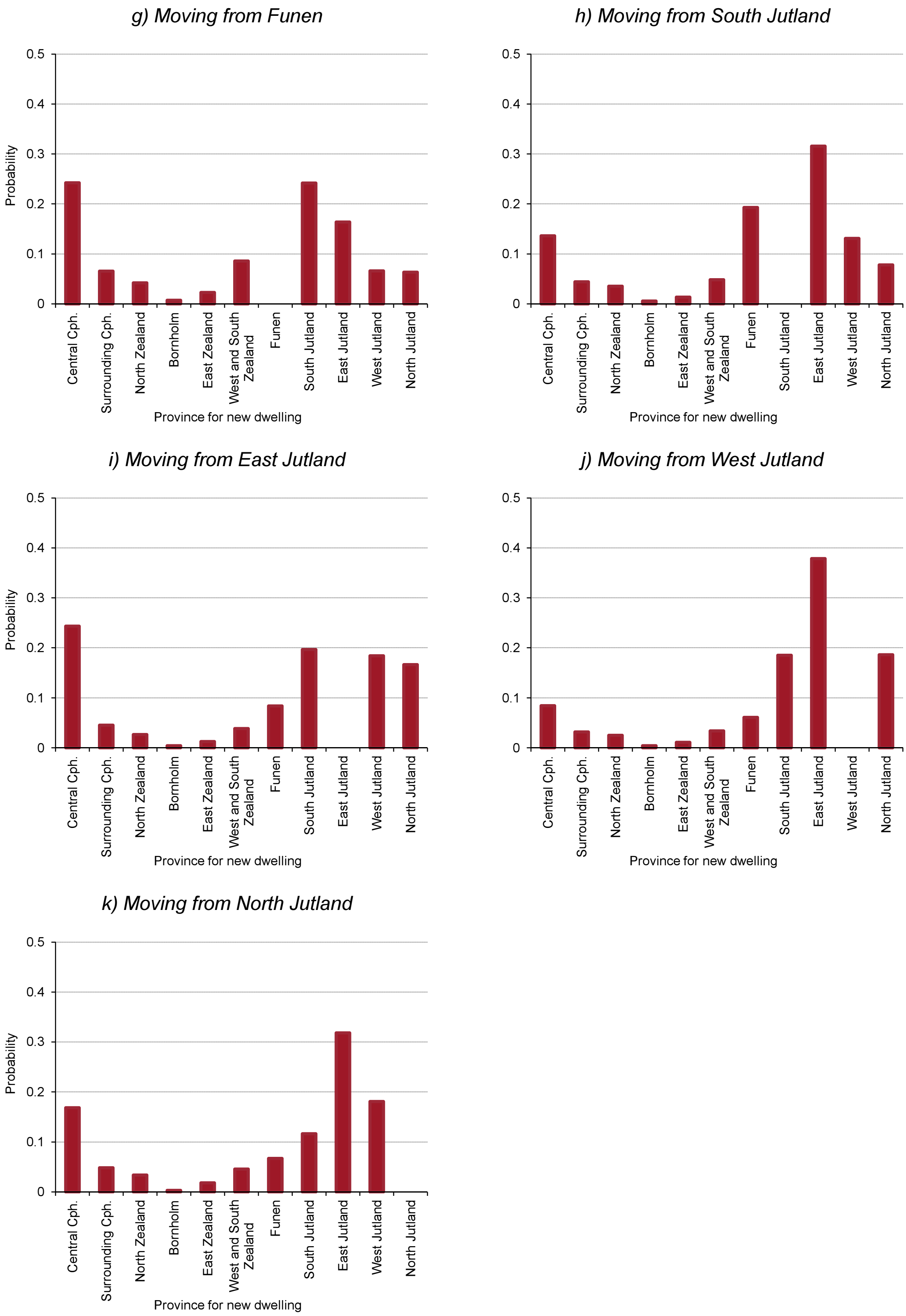
Note: *No distinction is made between the personal and family level, because there are no differences in dwelling characteristics.*

Figure A1. Estimated probabilities of moving to a given province conditional on from which province removals are effected (families who are not exposed to couple formation and dissolution, part 1), 2000–10.



(Continued)

Figure A1 (Continued). Estimated probabilities of moving to a given province conditional on from which province removals are effected (families who are not exposed to couple formation and dissolution, part 1), 2000–10.



Sources: *Statistics Denmark and own calculations.*

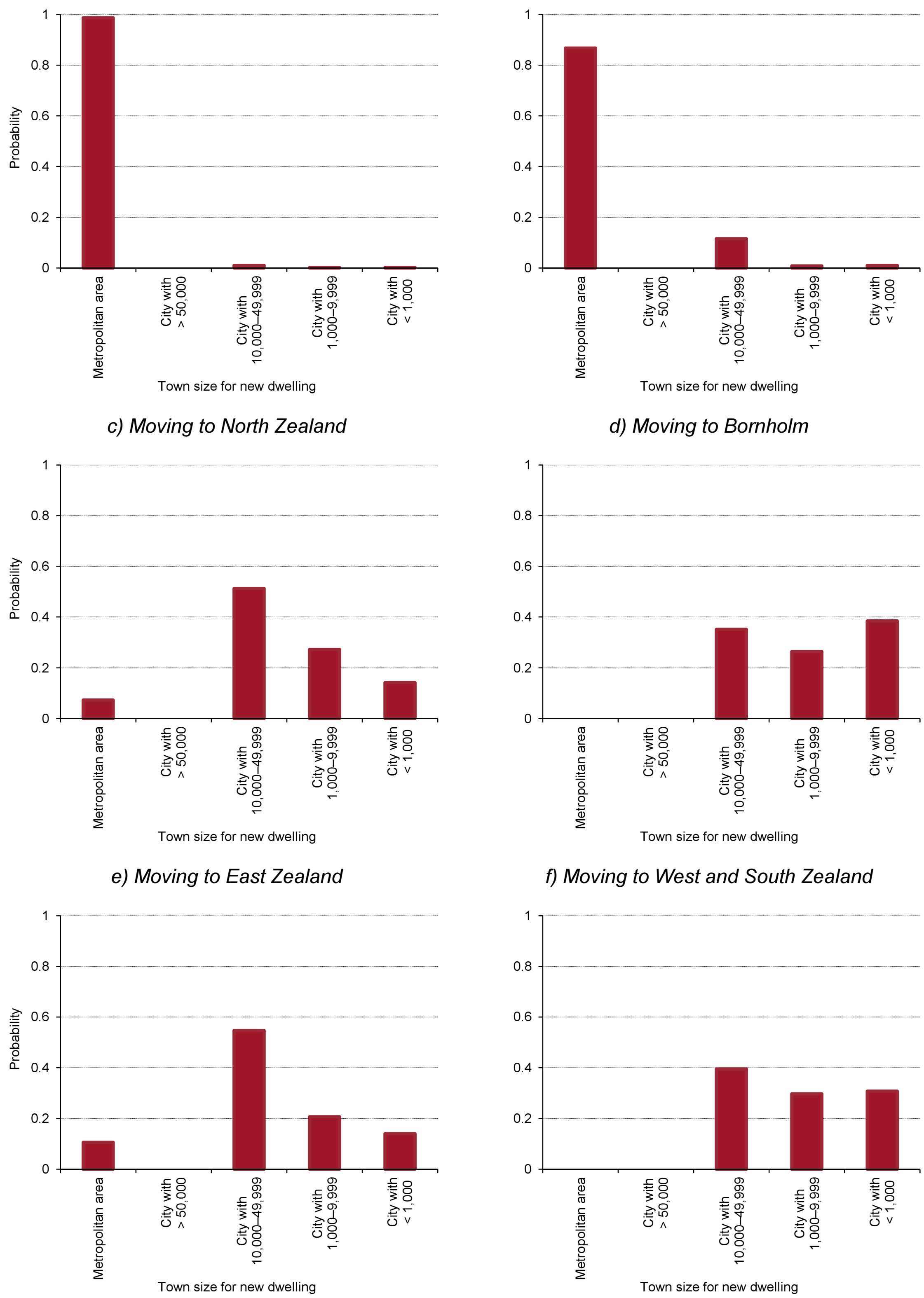
Note: *Probabilities are conditional on a movement across provinces, and are aggregated from terminal groups.*

Figure A.2. Estimated probabilities of moving to a given town size conditional on from which province removals are effected (families who are not exposed to couple formation and dissolution, part 1), 2000–10.

a) Moving to Central Copenhagen *b) Moving to Surrounding Copenhagen*

c) Moving to North Zealand *d) Moving to Bornholm*

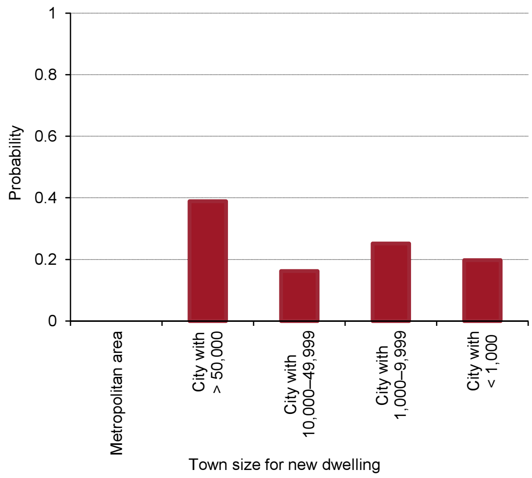
e) Moving to East Zealand *f) Moving to West and South Zealand*



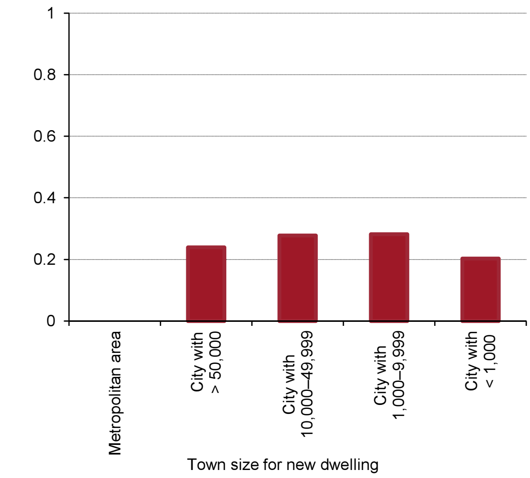
(Continued)

Figure A.2 (Continued). Estimated probabilities of moving to a given town size conditional on from which province removals are effected (families who are not exposed to couple formation and dissolution, part 1), 2000–10.

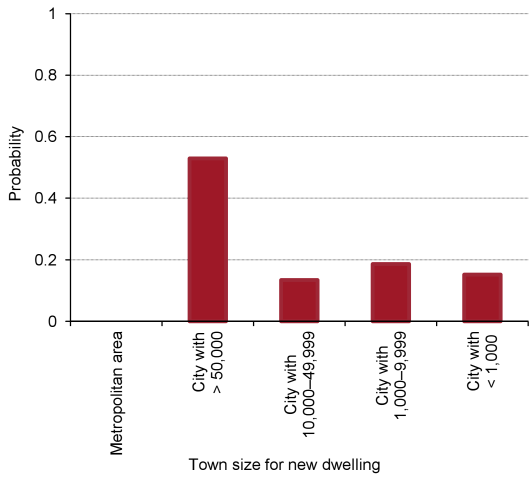
g) Moving to Funen



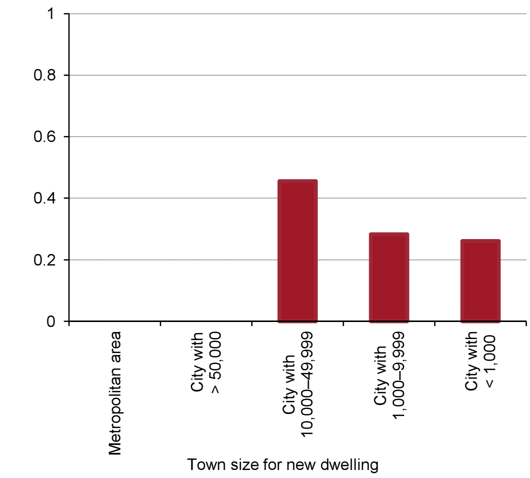
h) Moving to South Jutland



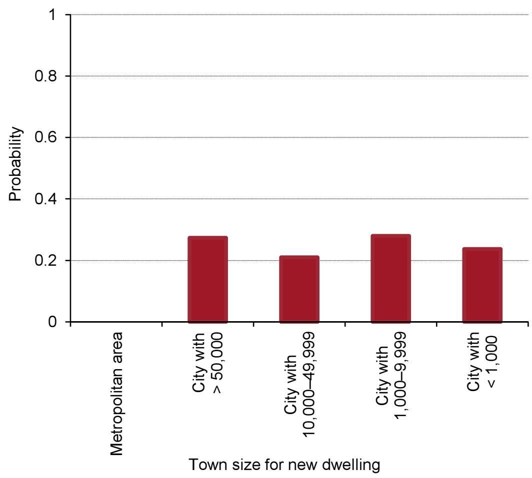
i) Moving to East Jutland



j) Moving to West Jutland



k) Moving to North Jutland



Sources: *Statistics Denmark and own calculations.*

Note: *Probabilities are conditional on a movement across provinces, and are aggregated from terminal groups.*

Appendix A4

Table A.3. Number of persons, families and households in Denmark, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	5,209,169	5,323,418	5,405,651	5,534,738	5,716,918	5,892,817	6,002,964
Children living at home	1,289,379	1,320,537	1,355,062	1,386,578	1,367,168	1,399,666	1,443,102
Adults up to 34 years old	1,116,461	1,074,350	985,608	956,542	1,020,741	1,036,128	1,013,252
Adults 35–64 years old	2,004,968	2,138,332	2,252,620	2,288,759	2,190,769	2,135,185	2,087,885
Adults 65–79 years old	593,493	581,402	591,522	675,349	876,643	918,625	995,317
Adults 80 years old or older	204,868	208,797	220,839	227,510	261,597	403,213	463,408
Number of families divided by couples and singles							
Total	2,628,447	2,679,966	2,725,849	2,815,778	2,997,186	3,125,212	3,193,669
Single men	592,484	609,046	637,570	684,342	774,722	830,040	863,943
Single women	744,620	748,005	763,539	799,054	869,900	927,233	963,533
Couples without children	671,532	707,758	722,269	729,557	763,396	768,118	752,948
Couples with children	619,811	615,157	602,471	602,825	589,168	599,821	613,245
Number of families divided by family size							
Total	2,628,447	2,679,966	2,725,849	2,815,778	2,997,186	3,125,212	3,193,669
1 person	1,193,154	1,216,190	1,246,207	1,312,195	1,470,959	1,579,962	1,645,358
2 persons	764,434	794,884	813,262	829,702	853,732	859,883	845,271
3 persons	304,769	285,760	271,729	272,548	285,332	287,453	288,970
4 persons	277,912	280,766	283,516	287,538	278,611	285,532	297,574
5 persons	72,288	82,820	89,739	93,053	88,968	91,943	95,419
6 or more persons	15,890	19,546	21,396	20,742	19,584	20,439	21,077
Number of families divided by couples and singles and number of children							
Total	2,628,447	2,679,966	2,725,849	2,815,778	2,997,186	3,125,212	3,193,669
Singles without children	1,193,154	1,216,190	1,246,207	1,312,195	1,470,959	1,579,962	1,645,358
Singles with 1 child	92,902	87,126	90,993	100,145	90,336	91,765	92,323
Singles with 2 children	40,955	42,015	49,213	54,835	62,046	64,271	67,316
Singles with 3 children	8,198	9,304	11,499	12,776	17,080	17,196	18,312
Singles with 4 or more children	1,895	2,416	3,197	3,445	3,222	3,184	3,239
Couples without children	671,532	707,758	722,269	729,557	764,375	769,013	753,876
Couples with 1 child	263,814	243,745	222,516	217,713	223,286	223,182	221,654
Couples with 2 children	269,714	271,462	272,017	274,762	261,531	268,336	279,262
Couples with 3 children	70,795	80,980	87,312	90,503	85,746	88,759	92,180
Couples with 4 or more children	15,488	18,970	20,626	19,847	18,605	19,544	20,149
Number of households							
Total	2,339,770	2,414,221	2,487,831	2,560,958	2,760,398	2,876,817	2,938,396
Number of families per household	1.123	1.110	1.096	1.100	1.086	1.086	1.087

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.4. Number of dwellings in Denmark divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	2,339,770	2,414,221	2,487,831	2,560,958	2,760,398	2,876,817	2,938,396
Owner-occupied housing	1,219,335	1,285,673	1,287,558	1,294,306	1,376,973	1,405,218	1,409,679
Social housing	450,533	474,955	484,549	494,333	564,439	594,122	610,664
Cooperative housing	125,240	156,009	177,461	191,885	227,064	249,421	262,755
Publicly owned rented housing	61,045	43,170	41,823	41,721	61,025	74,148	85,915
Privately owned rented housing	442,137	447,134	449,966	471,943	530,896	553,908	569,383
Unknown	41,480	7,280	46,474	66,770	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	2,339,770	2,414,221	2,487,831	2,560,958	2,760,398	2,876,817	2,938,396
Farmhouses	140,441	124,615	116,471	110,450	106,339	100,448	94,958
Detached houses	947,228	989,585	1,012,594	1,036,086	1,087,855	1,105,405	1,104,343
Terraced houses	291,329	306,205	338,899	368,289	410,729	440,221	454,760
Multi-dwelling houses	893,433	918,682	944,862	966,357	1,075,164	1,146,129	1,196,435
Student housing	26,910	28,689	28,458	29,816	33,260	33,693	33,868
Other residential buildings	7,538	7,481	7,300	6,199	8,593	8,885	9,113
Properties for commercial use	7,870	6,896	6,661	6,485	8,176	8,398	8,515
Residential institutions	13,006	16,091	8,351	7,704	9,266	10,845	12,948
Holiday houses	11,825	15,745	14,288	17,004	21,015	22,793	23,454
Unknown	190	232	9,947	12,568	-	-	-
Dwellings divided by area (dwelling size)							
Total	2,339,770	2,414,221	2,487,831	2,560,958	2,760,398	2,876,817	2,938,396
0–59 m^2	319,568	325,446	319,226	306,310	342,511	363,270	378,384
60–99 m^2	888,993	907,643	929,163	944,311	1,030,054	1,092,541	1,133,220
100–119 m^2	333,508	330,913	336,137	346,089	383,238	404,207	414,723
120–159 m^2	490,113	512,611	528,118	544,375	574,033	583,955	582,892
At least 160 m^2	307,588	337,608	365,397	407,516	430,562	432,844	429,176
Unknown	0	0	9,790	12,357	-	-	-
Dwellings divided by location (size of town)							
Total	2,339,770	2,414,221	2,487,831	2,560,958	2,760,398	2,876,817	2,938,396
Metropolitan area	669,137	551,998	536,427	588,790	648,723	700,319	741,967
City with at least 50,000 residents	317,467	326,802	342,997	403,166	428,093	442,627	450,459
City with 10,000–49,999 residents	424,714	532,606	567,036	562,714	619,411	648,255	662,725
City with 1,000–9,999 residents	460,506	520,439	517,555	543,857	586,606	605,347	610,600
City with less than 1,000 residents	467,946	482,376	469,902	462,430	477,564	480,269	472,644
Unknown	0	0	53,914	1	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Appendix A5

Table A.5. Number of persons, families and households in the Province of Central Copenhagen, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	608,914	636,171	644,919	678,873	759,799	832,623	886,424
Children living at home	101,356	113,759	123,184	134,503	158,271	176,008	186,406
Adults up to 34 years old	196,206	211,621	205,100	213,394	233,832	244,630	246,024
Adults 35–64 years old	201,070	217,980	235,003	250,567	270,547	295,011	310,259
Adults 65–79 years old	75,288	60,990	52,892	56,533	76,582	85,314	105,666
Adults 80 years old or older	34,994	31,821	28,740	23,876	20,567	31,660	38,069
Number of families divided by couples and singles							
Total	386,699	396,223	396,946	414,906	455,204	495,616	528,093
Single men	116,104	122,275	125,507	133,546	149,868	163,316	173,538
Single women	149,731	147,771	146,646	151,896	159,012	171,301	182,630
Couples without children	76,243	76,561	72,994	72,757	78,070	85,180	92,099
Couples with children	44,621	49,616	51,799	56,707	68,254	75,819	79,826
Number of families divided by family size							
Total	386,699	396,223	396,946	414,906	455,204	495,616	528,093
1 person	244,504	248,748	248,900	260,096	280,490	303,778	323,898
2 persons	91,392	91,018	88,207	89,134	95,020	103,462	110,954
3 persons	28,485	29,544	30,087	32,913	40,147	43,695	45,472
4 persons	17,329	20,245	22,004	24,535	30,829	34,698	36,812
5 persons	3,675	4,961	5,857	6,324	7,258	8,386	9,316
6 or more persons	1,314	1,707	1,891	1,904	1,460	1,597	1,641
Number of families divided by couples and singles and number of children							
Total	386,699	396,223	396,946	414,906	455,204	495,616	528,093
Singles without children	244,504	248,748	248,900	260,096	280,490	303,778	323,898
Singles with 1 child	15,149	14,457	15,213	16,377	16,950	18,282	18,855
Singles with 2 children	5,086	5,425	6,151	6,883	8,931	9,874	10,490
Singles with 3 children	883	1,064	1,393	1,529	2,013	2,224	2,427
Singles with 4 or more children	213	352	496	557	362	350	388
Couples without children	76,243	76,561	72,994	72,757	78,204	85,289	92,209
Couples with 1 child	23,399	24,119	23,936	26,030	31,216	33,821	34,982
Couples with 2 children	16,446	19,181	20,611	23,006	28,816	32,474	34,385
Couples with 3 children	3,505	4,697	5,490	5,922	6,896	8,036	8,928
Couples with 4 or more children	1,271	1,619	1,762	1,749	1,326	1,488	1,531
Number of households							
Total	341,671	347,678	346,642	354,957	395,887	431,414	460,254
Number of families per household	1.132	1.140	1.145	1.169	1.150	1.149	1.147

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.6. Number of dwellings in the Province of Central Copenhagen divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	341,671	347,678	346,642	354,957	395,887	431,414	460,254
Owner-occupied housing	65,452	72,181	71,770	73,339	91,010	102,532	111,892
Social housing	62,491	64,726	63,795	61,004	69,478	75,150	80,113
Cooperative housing	72,548	97,029	104,067	106,530	120,223	132,245	140,828
Publicly owned rented housing	23,288	5,500	5,108	5,229	6,906	7,820	8,719
Privately owned rented housing	115,742	108,001	95,365	99,824	108,270	113,667	118,702
Unknown	2,150	241	6,537	9,031	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	341,671	347,678	346,642	354,957	395,887	431,414	460,254
Farmhouses	127	98	86	81	218	239	229
Detached houses	24,684	25,107	25,176	25,253	29,944	32,971	35,842
Terraced houses	9,000	9,503	9,770	10,713	12,839	14,337	15,516
Multi-dwelling houses	296,839	302,360	304,133	308,990	344,059	374,718	399,106
Student housing	5710	5,799	5,957	7,880	7,096	7,294	7,476
Other residential buildings	96	101	135	148	207	190	227
Properties for commercial use	480	435	450	450	621	672	681
Residential institutions	4,654	4,184	335	356	677	741	890
Holiday houses	77	89	122	153	227	253	287
Unknown	4	2	478	933	-	-	-
Dwellings divided by area (dwelling size)							
Total	341,671	347,678	346,642	354,957	395,887	431,414	460,254
0–59 m^2	105,544	104,626	98,926	94,356	103,790	110,955	117,447
60–99 m^2	171,132	175,553	174,995	177,567	194,899	211,598	225,103
100–119 m^2	27,985	28,969	31,166	36,160	41,673	46,995	50,846
120–159 m^2	24,629	25,666	27,579	31,444	36,817	40,680	43,843
At least 160 m^2	12,381	12,864	13,500	14,509	18,709	21,187	23,015
Unknown	0	0	476	921	-	-	-
Dwellings divided by location (size of town)							
Total	341,671	347,678	346,642	354,957	395,887	431,414	460,254
Metropolitan area	341,671	342,328	320,630	349,103	389,299	424,917	453,390
City with at least 50,000 residents	0	0	1205	0	0	0	0
City with 10,000–49,999 residents	0	4,667	9,518	5,076	5,640	5,538	5,889
City with 1,000–9,999 residents	0	582	2,853	603	631	594	586
City with less than 1,000 residents	0	101	2,359	175	318	364	389
Unknown	0	0	10,077	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.7. Number of persons, families and households in the Province of Surrounding Copenhagen, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	495,212	500,964	503,980	512,692	542,161	576,800	605,793
Children living at home	122,547	126,765	130,797	134,937	141,016	150,843	158,873
Adults up to 34 years old	97,468	89,735	81,224	79,086	89,254	95,109	94,648
Adults 35–64 years old	198,436	206,118	212,075	212,095	211,136	215,487	222,033
Adults 65–79 years old	59,752	58,988	57,995	63,306	76,167	80,557	91,124
Adults 80 years old or older	17,009	19,358	21,889	23,268	24,588	34,804	39,115
Number of families divided by couples and singles							
Total	251,794	253,077	254,532	259,653	279,032	297,796	313,099
Single men	53,848	54,853	57,237	60,762	69,623	76,231	80,912
Single women	77,078	77,095	78,653	80,789	87,296	93,404	98,366
Couples without children	63,851	63,742	61,805	60,596	62,933	65,012	67,434
Couples with children	57,017	57,387	56,837	57,506	59,180	63,149	66,387
Number of families divided by family size							
Total	251,794	253,077	254,532	259,653	279,032	297,796	313,099
1 person	113,150	115,230	117,912	122,271	137,255	148,877	157,699
2 persons	75,438	74,155	72,497	72,047	73,217	75,731	78,360
3 persons	30,720	28,116	27,001	27,165	28,848	30,550	31,775
4 persons	25,522	27,212	27,916	28,305	29,035	31,028	33,024
5 persons	5,417	6,597	7,393	8,082	8,832	9,534	10,107
6 or more persons	1,547	1,767	1,813	1,783	1,845	2,076	2,134
Number of families divided by couples and singles and number of children							
Total	251,794	253,077	254,532	259,653	279,032	297,796	313,099
Singles without children	113,150	115,230	117,912	122,271	137,255	148,877	157,699
Singles with 1 child	11,587	10,413	10,692	11,451	10,284	10,719	10,926
Singles with 2 children	5,052	5,034	5,811	6,259	7,010	7,576	8,120
Singles with 3 children	928	1,052	1,185	1,261	1,921	2,015	2,077
Singles with 4 or more children	209	219	290	309	348	338	343
Couples without children	63,851	63,742	61,805	60,596	63,034	65,122	67,547
Couples with 1 child	25,668	23,082	21,190	20,906	21,838	22,974	23,655
Couples with 2 children	24,594	26,160	26,731	27,044	27,114	29,013	30,947
Couples with 3 children	5,264	6,417	7,156	7,834	8,484	9,196	9,764
Couples with 4 or more children	1,491	1,728	1,760	1,722	1,744	1,966	2,021
Number of households							
Total	227,116	230,523	233,590	237,331	258,225	275,336	289,298
Number of families per household	1.109	1.098	1.090	1.094	1.081	1.082	1.082

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.8. Number of dwellings in the Province of Surrounding Copenhagen divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	227,116	230,523	233,590	237,331	258,225	275,336	289,298
Owner-occupied housing	93,173	98,479	99,604	99,895	110,825	120,149	127,809
Social housing	84,596	86,580	85,710	84,378	86,666	88,111	89,764
Cooperative housing	9,605	10,741	12,766	14,571	16,594	18,069	19,290
Publicly owned rented housing	3,866	4,123	4,216	3,977	6,080	7,316	8,343
Privately owned rented housing	33,125	30,353	27,786	29,135	38,060	41,691	44,092
Unknown	2,751	247	3,508	5,375	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	227,116	230,523	233,590	237,331	258,225	275,336	289,298
Farmhouses	371	300	260	248	475	439	500
Detached houses	58,367	59,188	59,822	59,813	66,409	71,737	76,301
Terraced houses	42,269	42,488	43,774	44,836	48,201	50,567	52,437
Multi-dwelling houses	120,129	121,970	122,870	125,089	136,077	145,034	152,324
Student housing	4558	4610	4608	4685	5,082	5,335	5,370
Other residential buildings	449	498	304	234	524	615	623
Properties for commercial use	268	221	238	234	430	460	452
Residential institutions	591	1128	1,019	1,152	891	1,028	1,158
Holiday houses	105	109	76	72	134	122	131
Unknown	9	11	619	968	-	-	-
Dwellings divided by area (dwelling size)							
Total	227,116	230,523	233,590	237,331	258,225	275,336	289,298
0–59 m^2	37,653	38,286	37,735	36,938	40,548	44,173	46,132
60–99 m^2	108,335	109,087	109,603	110,404	116,612	122,179	127,495
100–119 m^2	33,429	33,542	33,862	34,693	39,521	42,733	45,630
120–159 m^2	32,590	33,738	34,868	36,032	40,019	42,740	45,097
At least 160 m^2	15,109	15,870	16,913	18,308	21,525	23,510	24,945
Unknown	0	0	609	956	-	-	-
Dwellings divided by location (size of town)							
Total	227,116	230,523	233,590	237,331	258,225	275,336	289,298
Metropolitan area	227,116	199,518	192,935	212,218	231,066	246,885	260,039
City with at least 50,000 residents	0	0	376	0	0	0	0
City with 10,000–49,999 residents	0	26,372	30,266	22,680	24,348	25,607	26,454
City with 1,000–9,999 residents	0	3,109	2,227	901	923	933	862
City with less than 1,000 residents	0	1,524	2,707	1,532	1,888	1,912	1,943
Unknown	0	0	5,079	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.9. Number of persons, families and households in the Province of North Zealand, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	408,060	424,505	436,246	446,451	456,981	471,226	486,743
Children living at home	107,800	113,039	119,411	123,603	117,969	117,977	123,513
Adults up to 34 years old	70,903	64,165	53,105	45,853	51,068	55,000	54,248
Adults 35–64 years old	176,432	188,800	197,741	197,161	186,675	181,613	178,841
Adults 65–79 years old	41,381	45,270	50,485	62,283	77,539	78,523	89,273
Adults 80 years old or older	11,544	13,231	15,504	17,551	23,730	38,113	40,868
Number of families divided by couples and singles							
Total	194,177	200,528	204,955	211,014	226,351	237,978	246,055
Single men	38,448	38,340	39,521	41,804	49,487	53,808	56,899
Single women	49,644	51,245	53,551	57,376	64,203	68,899	71,981
Couples without children	52,509	56,752	57,682	57,618	61,217	63,859	63,666
Couples with children	53,576	54,191	54,201	54,216	51,444	51,412	53,509
Number of families divided by family size							
Total	194,177	200,528	204,955	211,014	226,351	237,978	246,055
1 person	75,596	77,702	80,049	84,668	99,894	109,267	114,985
2 persons	60,604	64,048	65,232	65,813	68,089	70,593	70,292
3 persons	27,759	25,533	23,749	23,243	23,859	23,460	24,135
4 persons	24,262	25,696	26,973	27,799	25,205	25,024	26,625
5 persons	5,031	6,304	7,508	8,050	7,722	7,971	8,335
6 or more persons	925	1,245	1,444	1,441	1,582	1,663	1,683
Number of families divided by couples and singles and number of children							
Total	194,177	200,528	204,955	211,014	226,351	237,978	246,055
Singles without children	75,596	77,702	80,049	84,668	99,894	109,267	114,985
Singles with 1 child	8,095	7,296	7,550	8,195	6,872	6,734	6,626
Singles with 2 children	3,656	3,753	4,441	5,048	5,191	5,056	5,489
Singles with 3 children	625	681	843	1,044	1,439	1,347	1,469
Singles with 4 or more children	120	153	189	225	231	241	231
Couples without children	52,509	56,752	57,682	57,618	61,280	63,921	63,746
Couples with 1 child	24,103	21,780	19,308	18,195	18,668	18,404	18,646
Couples with 2 children	23,637	25,015	26,130	26,755	23,766	23,677	25,156
Couples with 3 children	4,932	6,178	7,362	7,854	7,491	7,730	8,104
Couples with 4 or more children	904	1,218	1,401	1,412	1,519	1,601	1,603
Number of households							
Total	168,778	177,703	184,253	190,754	207,812	218,481	225,881
Number of families per household	1.150	1.128	1.112	1.106	1.089	1.089	1.089

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.10. Number of dwellings in the Province of North Zealand divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	168,778	177,703	184,253	190,754	207,812	218,481	225,881
Owner-occupied housing	103,695	112,743	114,974	118,818	123,410	127,287	129,415
Social housing	31,158	32,631	33,821	35,829	41,163	43,418	45,289
Cooperative housing	3,844	4,913	6,779	6,686	9,234	10,450	11,049
Publicly owned rented housing	2,700	2,481	2,531	2,344	4,319	5,524	6,559
Privately owned rented housing	23,681	23,982	22,786	23,075	29,686	31,803	33,568
Unknown	3,700	953	3,362	4,002	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	168,778	177,703	184,253	190,754	207,812	218,481	225,881
Farmhouses	4,356	4,008	3,799	3,668	4,248	4,501	4,674
Detached houses	78,675	81,596	83,262	84,121	89,234	92,127	93,957
Terraced houses	32,267	34,162	37,395	41,674	43,133	45,174	46,284
Multi-dwelling houses	46,167	48,708	49,944	51,889	61,924	66,929	71,018
Student housing	867	908	846	837	1453	1,500	1,583
Other residential buildings	608	609	666	606	852	953	958
Properties for commercial use	370	389	441	440	659	702	710
Residential institutions	418	582	735	679	803	977	1,136
Holiday houses	5,032	6,719	5,865	5,782	5,505	5,618	5,560
Unknown	18	22	1,300	1,058	-	-	-
Dwellings divided by area (dwelling size)							
Total	168,778	177,703	184,253	190,754	207,812	218,481	225,881
0–59 m^2	15,705	16,502	16,167	15,660	19,078	20,590	21,851
60–99 m^2	56,538	60,031	61,165	62,885	69,437	73,928	77,383
100–119 m^2	26,592	27,134	27,764	28,926	32,502	34,736	35,733
120–159 m^2	45,543	47,661	49,418	50,805	52,659	54,392	55,125
At least 160 m^2	24,400	26,375	28,454	31,432	34,135	34,834	35,788
Unknown	0	0	1,285	1,046	-	-	-
Dwellings divided by location (size of town)							
Total	168,778	177,703	184,253	190,754	207,812	218,481	225,881
Metropolitan area	74,367	10,152	12,740	10,165	11,213	11,727	12,445
City with at least 50,000 residents	0	0	198	0	0	0	0
City with 10,000–49,999 residents	41,934	78,451	98,507	108,818	117,897	124,026	128,266
City with 1,000–9,999 residents	31,698	63,312	45,887	50,455	54,543	57,171	58,580
City with less than 1,000 residents	20,779	25,788	23,231	21,316	24,158	25,557	26,590
Unknown	0	0	3,690	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.11. Number of persons, families and households in the Province of Bornholm, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	44,883	44,304	43,429	42,255	40,459	38,925	37,323
Children living at home	11,274	10,840	10,243	9,545	8,185	7,771	7,786
Adults up to 34 years old	7,298	6,120	5,053	4,283	4,678	4,469	4,033
Adults 35–64 years old	18,009	19,132	19,789	19,229	16,045	13,837	12,618
Adults 65–79 years old	6,125	5,922	5,939	6,763	8,947	8,863	8,223
Adults 80 years old or older	2,177	2,290	2,405	2,435	2,604	3,985	4,663
Number of families divided by couples and singles							
Total	22,116	22,125	22,070	22,007	22,767	22,565	21,965
Single men	4,792	4,829	4,925	5,148	5,958	6,095	6,213
Single women	5,830	5,957	6,030	6,156	7,302	7,881	8,180
Couples without children	6,100	6,274	6,486	6,578	6,336	5,702	4,741
Couples with children	5,394	5,065	4,629	4,125	3,171	2,887	2,831
Number of families divided by family size							
Total	22,116	22,125	22,070	22,007	22,767	22,565	21,965
1 person	9,501	9,626	9,770	10,010	11,850	12,497	12,883
2 persons	6,806	6,957	7,190	7,353	7,070	6472	5,520
3 persons	2,464	2,419	2,159	1,968	1,691	1642	1,528
4 persons	2,507	2,292	2,143	1,928	1,532	1361	1,495
5 persons	699	678	664	608	504	476	432
6 or more persons	139	153	144	140	120	117	107
Number of families divided by couples and singles and number of children							
Total	22,116	22,125	22,070	22,007	22,767	22,565	21,965
Singles without children	9,501	9,626	9,770	10,010	11,850	12,497	12,883
Singles with 1 child	706	683	704	775	734	770	779
Singles with 2 children	341	381	382	411	492	541	560
Singles with 3 children	65	85	81	94	146	137	136
Singles with 4 or more children	9	11	18	14	31	23	29
Couples without children	6,100	6,274	6,486	6,578	6,343	5,710	4,747
Couples with 1 child	2,123	2,038	1,777	1,557	1,199	1,101	968
Couples with 2 children	2,442	2,207	2,062	1,834	1,386	1,224	1,359
Couples with 3 children	692	668	648	596	473	453	403
Couples with 4 or more children	137	152	142	138	113	109	101
Number of households							
Total	19,858	20,239	20,563	20,526	21,655	21,467	20,908
Number of families per household	1.114	1.093	1.073	1.072	1.051	1.051	1.051

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.12. Number of dwellings in the Province of Bornholm divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	19,858	20,239	20,563	20,526	21,655	21,467	20,908
Owner-occupied housing	14,346	14,617	14,303	14,054	13,791	12,999	12,076
Social housing	1,834	1,996	2,082	2,079	3,066	3,453	3,805
Cooperative housing	368	386	498	647	803	869	826
Publicly owned rented housing	438	483	434	450	533	678	710
Privately owned rented housing	2,391	2,721	2,853	2,886	3,463	3,469	3,491
Unknown	481	36	393	410	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	19,858	20,239	20,563	20,526	21,655	21,467	20,908
Farmhouses	2,273	2,021	1,869	1,780	1,739	1,539	1,459
Detached houses	10,638	10,943	10,966	10,880	10,824	10,336	9,527
Terraced houses	4,872	4,932	5,109	5,206	5,668	5,884	5,873
Multi-dwelling houses	1,653	1,763	2,037	2,113	2,743	3,003	3,285
Student housing	166	179	177	183	288	305	308
Other residential buildings	80	202	115	101	161	149	210
Properties for commercial use	92	85	95	76	95	104	96
Residential institutions	33	51	11	10	20	31	28
Holiday houses	49	59	72	86	118	116	122
Unknown	2	4	112	91	-	-	-
Dwellings divided by area (dwelling size)							
Total	19,858	20,239	20,563	20,526	21,655	21,467	20,908
0–59 m^2	1,336	1,334	1,298	1,223	1,523	1,650	1,733
60–99 m^2	6,858	6,908	7,021	6,956	7,696	7,928	8,171
100–119 m^2	3,379	3,380	3,323	3,297	3,771	3,855	3,658
120–159 m^2	4,748	4,855	4,905	4,886	4,327	3,898	3,574
At least 160 m^2	3,537	3,762	3,906	4,073	4,339	4,136	3,772
Unknown	0	0	110	91	-	-	-
Dwellings divided by location (size of town)							
Total	19,858	20,239	20,563	20,526	21,655	21,467	20,908
Metropolitan area	0	0	236	0	0	0	0
City with at least 50,000 residents	0	0	,38	0	0	0	0
City with 10,000–49,999 residents	6,731	6,945	6,875	7,190	7,843	8,041	7,946
City with 1,000–9,999 residents	5,457	5,146	5,376	5,942	6,700	6,708	6,702
City with less than 1,000 residents	7,670	8,148	7,612	7,394	7,113	6,717	6,260
Unknown	0	0	426	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.13. Number of persons, families and households in the Province of East Zealand, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	214,457	221,346	228,565	234,574	237,726	241,910	243,544
Children living at home	57,548	59,153	61,939	64,691	60,605	60,371	61,569
Adults up to 34 years old	41,897	38,810	33,491	28,842	32,609	34,283	33,011
Adults 35–64 years old	91,864	97,900	103,609	103,732	94,731	91,050	87,169
Adults 65–79 years old	17,948	19,663	22,961	29,984	39,135	37,345	42,533
Adults 80 years old or older	5,200	5,820	6,565	7,325	10,646	18,861	19,262
Number of families divided by couples and singles							
Total	100,274	103,369	106,878	110,466	118,708	123,745	124,778
Single men	19,260	19,461	20,571	22,261	26,930	29,642	30,347
Single women	24,382	25,083	26,554	28,788	33,365	36,309	37,234
Couples without children	27,465	29,962	31,172	30,744	32,115	31,967	30,809
Couples with children	29,167	28,863	28,581	28,673	26,298	25,827	26,388
Number of families divided by family size							
Total	100,274	103,369	106,878	110,466	118,708	123,745	124,778
1 person	37,098	38,262	40,401	43,371	52,810	58,400	60,017
2 persons	31,749	33,899	35,021	35,133	35,886	35,745	34,506
3 persons	15,424	14,023	12,961	12,477	12,501	12,254	12,261
4 persons	13,108	13,528	14,202	14,864	12,854	12,551	13,191
5 persons	2,407	3,033	3,552	3,881	3,903	3,944	4,020
6 or more persons	488	624	741	740	754	851	783
Number of families divided by couples and singles and number of children							
Total	100,274	103,369	106,878	110,466	118,708	123,745	124,778
Singles without children	37,098	38,262	40,401	43,371	52,810	58,400	60,017
Singles with 1 child	4,284	3,937	3,849	4,389	3,771	3,778	3,697
Singles with 2 children	1,861	1,915	2,337	2,662	2,831	2,825	2,890
Singles with 3 children	343	353	437	526	729	772	801
Singles with 4 or more children	56	77	101	101	125	143	144
Couples without children	27,465	29,962	31,172	30,744	32,144	32,000	30,841
Couples with 1 child	13,563	12,108	10,624	9,815	9,670	9,429	9,371
Couples with 2 children	12,765	13,175	13,765	14,338	12,125	11,779	12,390
Couples with 3 children	2,359	2,969	3,470	3,801	3,778	3,801	3,876
Couples with 4 or more children	480	611	722	719	725	818	751
Number of households							
Total	89,263	93,305	97,694	100,839	109,909	114,463	115,377
Number of families per household	1.123	1.108	1.094	1.095	1.080	1.081	1.081

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.14. Number of dwellings in the Province of East Zealand divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	89,263	93,305	97,694	100,839	109,909	114,463	115,377
Owner-occupied housing	53,484	57,388	58,359	59,978	62,148	63,329	63,212
Social housing	18,886	20,016	19,565	21,822	24,640	25,479	25,725
Cooperative housing	3,048	3,494	4,391	5,407	6,220	6,407	6,542
Publicly owned rented housing	1,134	986	1,299	1,506	2,413	3,247	3,565
Privately owned rented housing	11,211	11,151	12,258	9,959	14,489	16,002	16,333
Unknown	1,500	270	1,822	2,167	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	89,263	93,305	97,694	100,839	109,909	114,463	115,377
Farmhouses	2,922	2,525	2,400	2,328	2,852	3,029	2,992
Detached houses	43,349	45,638	47,549	47,975	50,513	51,412	51,280
Terraced houses	14,898	15,768	17,240	18,734	20,760	22,153	22,416
Multi-dwelling houses	25,468	26,268	27,185	28,001	31,722	33,655	34,372
Student housing	791	1,099	1,505	1,725	2,070	1,942	1,917
Other residential buildings	278	289	251	251	384	380	376
Properties for commercial use	202	199	225	223	347	337	387
Residential institutions	296	292	273	139	442	654	707
Holiday houses	1,050	1,223	365	707	820	902	930
Unknown	9	4	701	756	-	-	-
Dwellings divided by area (dwelling size)							
Total	89,263	93,305	97,694	100,839	109,909	114,463	115,377
0–59 m^2	9,627	10,005	10,092	9,823	11,175	11,591	12,017
60–99 m^2	30,063	31,202	32,188	32,879	37,043	39,606	39,954
100–119 m^2	14,486	14,531	14,865	15,304	16,904	17,724	17,932
120–159 m^2	23,535	24,879	25,891	26,571	27,290	27,382	27,072
At least 160 m^2	11,552	12,688	13,964	15,518	17,497	18,161	18,402
Unknown	0	0	694	744	-	-	-
Dwellings divided by location (size of town)							
Total	89,263	93,305	97,694	100,839	109,909	114,463	115,377
Metropolitan area	25,983	0	1,574	17,304	17,145	16,789	16,094
City with at least 50,000 residents	0	0	134	0	0	0	0
City with 10,000–49,999 residents	34,755	58,630	61,822	49,452	54,768	58,120	59,231
City with 1,000–9,999 residents	18,311	22,970	20,733	22,377	24,388	25,148	25,329
City with less than 1,000 residents	10,214	11,705	11,796	11,706	13,608	14,407	14,723
Unknown	0	0	1,635	0	-	-	-

Sources: Statistics Denmark and own calculations.

Note: Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.

Table A.15. Number of persons, families and households in the Province of West and South Zealand, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	553,845	563,821	576,975	585,990	584,482	583,920	579,591
Children living at home	136,129	138,020	141,673	143,044	134,558	132,870	134,043
Adults up to 34 years old	100,977	93,703	85,438	79,606	79,782	78,666	76,053
Adults 35–64 years old	223,397	239,080	253,383	255,464	233,664	217,253	203,676
Adults 65–79 years old	70,419	69,487	70,993	81,611	107,199	108,775	113,592
Adults 80 years old or older	22,923	23,531	25,488	26,265	29,279	46,356	52,227
Number of families divided by couples and singles							
Total	274,592	279,854	287,608	296,127	306,261	311,012	309,710
Single men	59,469	60,844	64,229	69,201	76,435	80,519	81,758
Single women	72,001	73,066	75,688	80,107	86,163	90,455	92,114
Couples without children	76,116	80,578	83,920	84,784	86,828	83,976	79,459
Couples with children	67,006	65,366	63,771	62,035	56,835	56,062	56,379
Number of families divided by family size							
Total	274,592	279,854	287,608	296,127	306,261	311,012	309,710
1 person	116,938	119,219	123,287	130,301	144,609	153,483	156,301
2 persons	85,301	89,476	93,561	95,805	95,841	92,671	88,093
3 persons	33,565	31,369	30,119	29,636	28,385	27,641	27,267
4 persons	30,238	29,903	29,836	29,420	26,588	26,499	27,391
5 persons	7,036	7,955	8,646	8,862	8,884	8,723	8,760
6 or more persons	1,514	1,932	2,159	2,103	1,954	1,995	1,898
Number of families divided by couples and singles and number of children							
Total	274,592	279,854	287,608	296,127	306,261	311,012	309,710
Singles without children	116,938	119,219	123,287	130,301	144,609	153,483	156,301
Singles with 1 child	9,185	8,898	9,641	11,021	9,013	8,695	8,634
Singles with 2 children	4,226	4,437	5,366	6,120	6,596	6,528	6,661
Singles with 3 children	907	1,071	1,293	1,471	1,898	1,837	1,887
Singles with 4 or more children	214	285	330	395	381	341	312
Couples without children	76,116	80,578	83,920	84,784	86,929	84,066	79,536
Couples with 1 child	29,339	26,932	24,753	23,516	21,789	21,113	20,606
Couples with 2 children	29,331	28,832	28,543	27,949	24,690	24,662	25,504
Couples with 3 children	6,869	7,740	8,394	8,577	8,503	8,382	8,448
Couples with 4 or more children	1,467	1,862	2,081	1,993	1,853	1,905	1,821
Number of households							
Total	243,673	251,899	261,593	270,207	283,897	288,380	287,292
Number of families per household	1.127	1.111	1.099	1.096	1.079	1.078	1.078

Sources: Statistics Denmark and own calculations.

Note: Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.

Table A.16. Number of dwellings in the Province of West and South Zealand divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	243,673	251,899	261,593	270,207	283,897	288,380	287,292
Owner-occupied housing	150,232	158,236	160,065	162,877	166,285	164,281	160,772
Social housing	36,691	39,312	41,365	44,220	52,143	54,698	55,328
Cooperative housing	5,430	6,017	7,157	10,394	12,325	13,326	13,801
Publicly owned rented housing	5,320	5,598	5,017	4,842	7,013	8,476	9,478
Privately owned rented housing	40,003	41,798	42,870	40,537	46,132	47,600	47,913
Unknown	5,997	938	5,119	7,337	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	243,673	251,899	261,593	270,207	283,897	288,380	287,292
Farmhouses	22,554	19,699	18,077	17,106	15,894	14,661	13,800
Detached houses	127,487	132,804	136,543	138,238	140,968	139,850	137,107
Terraced houses	30,591	32,587	37,077	42,442	46,850	49,997	50,866
Multi-dwelling houses	55,713	57,784	60,272	61,693	69,821	73,413	74,599
Student housing	1,259	1,357	1,094	899	1,600	1,594	1,593
Other residential buildings	926	877	1,067	855	1,153	1,160	1,138
Properties for commercial use	1,044	910	1,012	983	1,002	979	978
Residential institutions	1,276	2,034	1,187	972	1,349	1,540	1,924
Holiday houses	2,793	3,818	3,624	4,959	5,259	5,186	5,287
Unknown	30	29	1,640	2,060	-	-	-
Dwellings divided by area (dwelling size)							
Total	243,673	251,899	261,593	270,207	283,897	288,380	287,292
0–59 m^2	23,438	24,183	23,620	21,758	25,384	27,002	27,741
60–99 m^2	87,019	88,717	90,932	93,222	100,439	104,580	105,838
100–119 m^2	38,239	38,438	38,899	40,141	42,266	42,639	42,365
120–159 m^2	57,763	60,154	62,771	64,967	67,258	66,839	65,439
At least 160 m^2	37,214	40,407	43,753	48,090	48,551	47,320	45,909
Unknown	0	0	1,618	2,029	-	-	-
Dwellings divided by location (size of town)							
Total	243,673	251,899	261,593	270,207	283,897	288,380	287,292
Metropolitan area	0	0	2,470	0	0	0	0
City with at least 50,000 residents	0	0	415	0	0	0	0
City with 10,000–49,999 residents	85,746	89,116	89,912	102,264	110,161	112,880	113,295
City with 1,000–9,999 residents	68,132	70,648	76,169	79,470	84,920	87,330	87,651
City with less than 1,000 residents	89,795	92,135	86,908	88,473	88,817	88,170	86,345
Unknown	0	0	5,719	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.17. Number of persons, families and households in the Province of Funen, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	467,277	471,537	476,211	484,862	490,439	495,641	498,226
Children living at home	115,298	115,832	117,534	119,627	113,874	114,098	116,941
Adults up to 34 years old	97,983	91,769	82,839	78,748	82,032	81,594	79,035
Adults 35–64 years old	178,460	189,231	198,694	201,416	187,794	176,685	168,347
Adults 65–79 years old	55,762	54,374	55,911	62,947	81,164	84,919	89,486
Adults 80 years old or older	19,774	20,331	21,233	22,124	25,575	38,345	44,417
Number of families divided by couples and singles							
Total	233,506	235,635	239,144	245,383	257,646	263,865	265,875
Single men	50,938	51,330	54,182	57,815	65,126	68,776	70,852
Single women	64,096	64,234	65,423	67,716	73,601	77,411	79,613
Couples without children	62,270	65,550	67,117	67,615	69,849	68,975	66,165
Couples with children	56,202	54,521	52,422	52,237	49,070	48,703	49,245
Number of families divided by family size							
Total	233,506	235,635	239,144	245,383	257,646	263,865	265,875
1 person	102,600	103,522	106,406	110,977	124,386	131,795	135,696
2 persons	70,164	72,911	74,835	76,043	77,286	76,342	73,505
3 persons	27,592	25,333	23,415	23,619	23,728	23,289	23,105
4 persons	25,741	25,257	25,127	25,156	23,040	23,076	23,905
5 persons	6,180	7,027	7,500	7,790	7,537	7,707	7,901
6 or more persons	1,229	1,585	1,861	1,798	1,669	1,656	1,763
Number of families divided by couples and singles and number of children							
Total	233,506	235,635	239,144	245,383	257,646	263,865	265,875
Singles without children	102,600	103,522	106,406	110,977	124,386	131,795	135,696
Singles with 1 child	7,894	7361	7,718	8,428	7,437	7,367	7,340
Singles with 2 children	3,626	3625	4,155	4,699	5,129	5,250	5,543
Singles with 3 children	733	845	1,038	1,098	1,400	1,416	1,526
Singles with 4 or more children	181	211	288	329	285	287	278
Couples without children	62,270	65,550	67,117	67,615	69,939	69,047	66,247
Couples with 1 child	23,966	21,708	19,260	18,920	18,599	18,039	17,562
Couples with 2 children	25,008	24,412	24,089	24,058	21,640	21,660	22,379
Couples with 3 children	6,046	6,879	7,295	7,563	7,252	7,420	7,623
Couples with 4 or more children	1,182	1,522	1,778	1,696	1,579	1,584	1,681
Number of households							
Total	206,888	212,763	220,398	226,478	239,819	245,584	247,448
Number of families per household	1.129	1.107	1.085	1.083	1.074	1.074	1.074

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.18. Number of dwellings in the Province of Funen divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	206,888	212,763	220,398	226,478	239,819	245,584	247,448
Owner-occupied housing	121,068	125,690	123,839	108,412	126,258	126,414	124,625
Social housing	33,039	34,949	35,448	35,722	43,464	45,826	46,620
Cooperative housing	4,400	4,864	6,262	7,490	9,325	10,040	10,296
Publicly owned rented housing	4,503	4,130	3,515	2,757	5,429	6,541	7,808
Privately owned rented housing	39,388	42,556	47,331	62,563	55,343	56,763	58,099
Unknown	4,490	574	4,003	9,534	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	206,888	212,763	220,398	226,478	239,819	245,584	247,448
Farmhouses	15,663	12,872	11,592	11,058	10,916	10,705	10,326
Detached houses	97,752	102,278	103,894	106,376	109,815	109,947	108,785
Terraced houses	36,154	38,245	42,024	44,818	45,177	46,958	47,515
Multi-dwelling houses	51,356	52,967	55,711	56,764	66,422	69,973	72,211
Student housing	2,495	2,648	2,928	2,958	3,172	3,157	3,137
Other residential buildings	1,073	1,058	961	899	971	999	1,005
Properties for commercial use	710	634	614	588	791	844	843
Residential institutions	1,498	1,770	1,498	1,478	1,527	1,818	2,313
Holiday houses	176	269	426	552	1,028	1,184	1,313
Unknown	11	22	750	987	-	-	-
Dwellings divided by area (dwelling size)							
Total	206,888	212,763	220,398	226,478	239,819	245,584	247,448
0–59 m^2	21,677	22,477	22,742	21,893	24,161	24,799	25,673
60–99 m^2	75,600	76,352	79,851	81,178	85,664	89,539	91,700
100–119 m^2	32,982	32,398	32,400	32,406	35,197	36,095	35,960
120–159 m^2	46,631	48,657	49,606	51,005	53,729	54,016	53,459
At least 160 m^2	29,998	32,879	35,061	39,024	41,069	41,135	40,656
Unknown	0	0	738	972	-	-	-
Dwellings divided by location (size of town)							
Total	206,888	212,763	220,398	226,478	239,819	245,584	247,448
Metropolitan area	0	0	1,235	0	0	0	0
City with at least 50,000 residents	70,325	71,887	71,662	83,358	87,339	88,828	89,711
City with 10,000–49,999 residents	25,888	27,058	27,832	29,283	34,984	37,768	39,560
City with 1,000–9,999 residents	57,861	59,992	62,494	61,112	63,718	64,807	64,568
City with less than 1,000 residents	52,814	53,826	52,330	52,724	53,779	54,181	53,611
Unknown	0	0	4,845	1	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.19. Number of persons, families and households in the Province of South Jutland, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	687,939	698,944	705,307	715,415	721,614	724,991	718,952
Children living at home	183,249	184,798	186,176	187,131	175,850	174,155	174,491
Adults up to 34 years old	138,490	129,205	114,750	107,172	111,572	110,185	104,303
Adults 35–64 years old	264,234	281,170	295,120	298,819	280,455	261,701	245,834
Adults 65–79 years old	76,020	78,242	81,132	92,337	117,186	124,592	130,815
Adults 80 years old or older	25,946	25,529	28,129	29,956	36,551	54,358	63,509
Number of families divided by couples and singles							
Total	327,233	333,081	338,844	347,567	366,566	374,312	373,543
Single men	67,781	69,645	73,923	78,746	89,390	93,983	96,298
Single women	81,990	82,370	84,637	88,104	97,978	103,805	106,327
Couples without children	89,125	94,962	97,604	99,248	103,597	102,230	96,962
Couples with children	88,337	86,104	82,680	81,469	75,601	74,294	73,956
Number of families divided by family size							
Total	327,233	333,081	338,844	347,567	366,566	374,312	373,543
1 person	133,820	136,049	140,529	146,785	167,507	177,980	182,838
2 persons	98,893	104,414	107,823	110,565	113,296	111,846	106,464
3 persons	39,577	36,692	34,371	34,562	34,819	33,830	32,997
4 persons	40,253	39,510	38,842	38,413	35,563	35,325	35,945
5 persons	12,150	13,319	13,951	14,088	12,407	12,391	12,342
6 or more persons	2,540	3,097	3,328	3,154	2,974	2,940	2,957
Number of families divided by couples and singles and number of children							
Total	327,233	333,081	338,844	347,567	366,566	374,312	373,543
Singles without children	133,820	136,049	140,529	146,785	167,507	177,980	182,838
Singles with 1 child	9,768	9,452	10,219	11,317	9,699	9,616	9,502
Singles with 2 children	4,803	4,964	5,844	6,616	7,416	7,401	7,509
Singles with 3 children	1,108	1,232	1,512	1,678	2,173	2,222	2,236
Singles with 4 or more children	272	318	456	454	438	437	442
Couples without children	89,125	94,962	97,604	99,248	103,732	102,362	97,060
Couples with 1 child	34,774	31,728	28,527	27,946	27,403	26,429	25,488
Couples with 2 children	39,145	38,278	37,330	36,735	33,390	33,103	33,709
Couples with 3 children	11,930	13,075	13,605	13,754	11,969	11,954	11,900
Couples with 4 or more children	2,488	3,023	3,218	3,034	2,839	2,808	2,859
Number of households							
Total	295,735	306,272	317,172	324,807	345,309	352,451	351,665
Number of families per household	1.107	1.088	1.068	1.070	1.062	1.062	1.062

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.20. Number of dwellings in the Province of South Jutland divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	295,735	306,272	317,172	324,807	345,309	352,451	351,665
Owner-occupied housing	171,556	179,808	179,557	183,652	191,477	191,439	187,851
Social housing	58,216	61,840	63,955	65,221	72,340	74,850	75,316
Cooperative housing	6,447	7,469	9,286	10,891	14,501	16,231	16,932
Publicly owned rented housing	6,684	6,580	6,426	5,961	7,978	9,418	10,702
Privately owned rented housing	46,756	49,474	51,500	50,938	59,012	60,514	60,864
Unknown	6,076	1,101	6,448	8,144	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	295,735	306,272	317,172	324,807	345,309	352,451	351,665
Farmhouses	24,955	22,528	21,136	19,868	19,236	18,355	17,377
Detached houses	148,430	156,391	160,079	165,693	171,712	171,316	167,855
Terraced houses	36,448	38,176	43,400	46,612	54,243	58,912	61,306
Multi-dwelling houses	79,696	82,345	85,593	85,664	92,628	95,989	97,014
Student housing	2,635	2,795	2,458	2,117	2,651	2,497	2,474
Other residential buildings	931	873	808	704	1,090	1,158	1,168
Properties for commercial use	1,314	1,133	1,019	975	1,144	1,123	1,065
Residential institutions	1,072	1,752	1,088	800	1,142	1,317	1,557
Holiday houses	222	245	386	745	1,462	1,784	1,849
Unknown	32	34	1,205	1,629	-	-	-
Dwellings divided by area (dwelling size)							
Total	295,735	306,272	317,172	324,807	345,309	352,451	351,665
0–59 m^2	27,071	27,677	27,451	24,779	28,815	29,799	30,531
60–99 m^2	100,650	102,543	105,858	106,459	115,043	120,927	123,729
100–119 m^2	44,985	43,414	43,742	43,891	48,794	50,766	51,098
120–159 m^2	74,441	77,769	79,192	80,650	83,709	82,926	80,771
At least 160 m^2	48,588	54,869	59,746	67,424	68,946	68,033	65,536
Unknown	0	0	1,183	1,604	-	-	-
Dwellings divided by location (size of town)							
Total	295,735	306,272	317,172	324,807	345,309	352,451	351,665
Metropolitan area	0	0	1,144	0	0	0	0
City with at least 50,000 residents	57,227	59,304	60,207	87,848	92,023	93,251	92,952
City with 10,000–49,999 residents	73,441	78,678	78,676	58,970	65,966	69,489	70,774
City with 1,000–9,999 residents	87,841	90,924	95,648	103,100	109,475	112,051	111,934
City with less than 1,000 residents	77,226	77,366	74,983	74,889	77,845	77,660	76,006
Unknown	0	0	6,514	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.21. Number of persons, families and households in the Province of East Jutland, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	744,529	766,786	791,882	826,923	877,526	924,475	956,324
Children living at home	190,199	195,304	202,880	210,880	215,844	228,243	239,372
Adults up to 34 years old	170,885	165,879	158,334	159,878	172,820	173,751	171,137
Adults 35–64 years old	280,112	302,525	322,698	334,044	325,944	328,499	327,739
Adults 65–79 years old	76,775	76,088	78,790	91,385	126,239	134,930	147,573
Adults 80 years old or older	26,558	26,990	29,180	30,736	36,679	59,052	70,503
Number of families divided by couples and singles							
Total	370,895	381,068	394,081	416,066	451,931	478,815	495,501
Single men	84,003	86,563	91,182	100,637	114,963	124,385	130,584
Single women	103,460	104,092	107,980	115,452	127,217	137,013	143,466
Couples without children	92,482	99,939	104,736	108,109	115,608	118,533	119,124
Couples with children	90,950	90,474	90,183	91,868	94,143	98,884	102,327
Number of families divided by family size							
Total	370,895	381,068	394,081	416,066	451,931	478,815	495,501
1 person	167,004	170,796	177,383	191,953	216,940	234,978	246,429
2 persons	105,421	112,009	117,223	122,003	128,362	131,911	132,690
3 persons	43,541	40,735	39,245	39,466	44,149	45,534	46,315
4 persons	41,484	41,575	42,956	44,638	44,996	47,338	49,708
5 persons	11,197	13,123	14,131	14,891	14,395	15,640	16,541
6 or more persons	2,248	2,830	3,143	3,115	3,089	3,414	3,818
Number of families divided by couples and singles and number of children							
Total	370,895	381,068	394,081	416,066	451,931	478,815	495,501
Singles without children	167,004	170,796	177,383	191,953	216,940	234,978	246,429
Singles with 1 child	12,939	12,070	12,487	13,894	12,754	13,378	13,566
Singles with 2 children	5,948	6,007	7,033	7,793	9,213	9,829	10,465
Singles with 3 children	1,237	1,384	1,732	1,910	2,624	2,555	2,861
Singles with 4 or more children	335	398	527	539	476	521	554
Couples without children	92,482	99,939	104,736	108,109	115,781	118,670	119,299
Couples with 1 child	37,593	34,728	32,212	31,673	34,936	35,705	35,850
Couples with 2 children	40,247	40,191	41,224	42,728	42,372	44,783	46,847
Couples with 3 children	10,935	12,838	13,741	14,518	13,919	15,119	15,987
Couples with 4 or more children	2,175	2,717	3,006	2,949	2,916	3,277	3,643
Number of households							
Total	325,917	340,003	357,632	375,688	414,768	439,724	455,142
Number of families per household	1.138	1.121	1.102	1.107	1.090	1.089	1.089

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.22. Number of dwellings in the Province of East Jutland divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	325,917	340,003	357,632	375,688	414,768	439,724	455,142
Owner-occupied housing	176,771	187,173	188,917	195,175	211,682	221,871	226,944
Social housing	62,937	67,234	69,544	72,089	84,674	90,590	94,037
Cooperative housing	9,527	10,275	13,308	15,088	18,667	20,450	21,403
Publicly owned rented housing	5,957	5,920	5,895	5,984	9,310	11,736	14,322
Privately owned rented housing	66,077	67,997	73,451	77,650	90,435	95,077	98,436
Unknown	4,648	1,404	6,517	9702	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	325,917	340,003	357,632	375,688	414,768	439,724	455,142
Farmhouses	20,914	18,222	16,915	16,007	16,071	15,649	15,180
Detached houses	138,613	147,355	153,023	160,072	176,426	185,762	191,015
Terraced houses	39,174	41,771	48,145	53,368	62,224	68,092	71,516
Multi-dwelling houses	116,419	120,502	126,993	133,764	147,003	156,070	162,763
Student housing	5,381	5,907	5,968	5,797	6,094	6,375	6,352
Other residential buildings	1,230	1,148	1,189	904	1,477	1,533	1,684
Properties for commercial use	1,378	1,222	1,102	1,115	1,446	1,541	1,608
Residential institutions	1,261	1,806	1,024	628	682	738	802
Holiday houses	1,519	2,042	1,977	2,038	3,346	3,965	4,223
Unknown	28	28	1,296	1,995	-	-	-
Dwellings divided by area (dwelling size)							
Total	325,917	340,003	357,632	375,688	414,768	439,724	455,142
0–59 m^2	41,879	43,531	44,588	45,270	48,041	50,820	52,204
60–99 m^2	117,524	120,649	126,187	129,825	147,545	158,585	166,906
100–119 m^2	47,480	47,194	49,019	50,190	57,001	61,317	63,801
120–159 m^2	71,970	76,667	79,533	82,763	90,654	95,265	96,886
At least 160 m^2	47,064	51,962	57,029	65,682	71,527	73,737	75,344
Unknown	0	0	1,276	1,958	-	-	-
Dwellings divided by location (size of town)							
Total	325,917	340,003	357,632	375,688	414,768	439,724	455,142
Metropolitan area	0	0	2,006	0	0	0	0
City with at least 50,000 residents	130,455	134,282	156,742	177,446	190,529	200,650	207,175
City with 10,000–49,999 residents	49,910	52,080	41,168	47,626	55,862	60,139	63,139
City with 1,000–9,999 residents	73,912	80,652	77,744	81,340	93,144	99,907	104,363
City with less than 1,000 residents	71,640	72,989	73,132	69,276	75,232	79,029	80,465
Unknown	0	0	6,840	0	-	-	-

Sources: *Statistics Denmark and own calculations.*

Note: *Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.*

Table A.23. Number of persons, families and households in the Province of West Jutland, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	409,886	415,343	418,839	427,075	431,048	430,055	426,088
Children living at home	114,222	113,694	114,126	114,905	107,653	104,307	105,279
Adults up to 34 years old	80,425	75,899	68,189	64,959	67,331	66,559	63,292
Adults 35–64 years old	155,402	165,406	173,711	176,832	164,941	152,928	143,566
Adults 65–79 years old	44,595	44,765	46,656	52,748	69,543	73,603	74,972
Adults 80 years old or older	15,242	15,579	16,157	17,631	21,580	32,658	38,979
Number of families divided by couples and singles							
Total	190,341	194,015	196,917	203,469	215,100	219,666	218,613
Single men	39,120	40,429	42,547	46,131	52,439	55,796	57,302
Single women	45,898	45,953	46,572	48,637	54,366	57,788	59,115
Couples without children	50,426	54,502	56,857	58,561	61,606	60,664	56,895
Couples with children	54,897	53,131	50,941	50,140	46,689	45,418	45,301
Number of families divided by family size							
Total	190,341	194,015	196,917	203,469	215,100	219,666	218,613
1 person	76,835	78,404	80,100	84,502	96,247	103,277	105,962
2 persons	55,539	59,227	61,821	64,176	66,838	65,734	61,911
3 persons	22,837	21,377	20,128	19,925	19,820	19,502	18,914
4 persons	24,550	23,481	22,737	22,686	21,910	21,535	22,059
5 persons	8,636	9,244	9,705	9,936	8,295	7,700	7,875
6 or more persons	1,944	2,282	2,426	2,244	1,990	1,918	1,892
Number of families divided by couples and singles and number of children							
Total	190,341	194,015	196,917	203,469	215,100	219,666	218,613
Singles without children	76,835	78,404	80,100	84,502	96,247	103,277	105,962
Singles with 1 child	5,113	4,725	4,964	5,615	5,232	5,070	5,016
Singles with 2 children	2,409	2,507	3,026	3,484	3,826	3,839	3,902
Singles with 3 children	552	603	838	940	1,210	1,129	1,240
Singles with 4 or more children	109	143	191	227	223	200	225
Couples without children	50,426	54,502	56,857	58,561	61,673	60,733	56,967
Couples with 1 child	20,428	18,870	17,102	16,441	15,994	15,663	15,012
Couples with 2 children	23,998	22,878	21,899	21,746	20,700	20,406	20,819
Couples with 3 children	8,545	9,129	9,554	9,769	8,072	7,500	7,650
Couples with 4 or more children	1,926	2,254	2,386	2,184	1,923	1,849	1,820
Number of households							
Total	170,947	177,329	184,003	189,912	203,036	207,262	206,227
Number of families per household	1.113	1.094	1.070	1.071	1.059	1.060	1.060

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.24. Number of dwellings in the Province of West Jutland divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	170,947	177,329	184,003	189,912	203,036	207,262	206,227
Owner-occupied housing	113,618	118,360	117,593	119,929	122,250	120,544	116,933
Social housing	23,101	25,759	27,774	28,953	35,263	37,622	38,490
Cooperative housing	3,239	3,369	4,017	4,740	7,209	8,525	8,702
Publicly owned rented housing	2,818	2,825	3,138	3,832	4,714	5,539	6,531
Privately owned rented housing	24,249	26,493	27,948	28,011	33,600	35,032	35,572
Unknown	3,922	523	3,533	4,447	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	170,947	177,329	184,003	189,912	203,036	207,262	206,227
Farmhouses	20,471	18,522	17,534	17,052	15,659	14,312	13,155
Detached houses	91,845	96,509	98,905	102,194	105,413	105,090	102,351
Terraced houses	18,018	19,637	22,117	24,098	29,278	32,430	33,889
Multi-dwelling houses	36,732	38,315	41,377	42,084	47,852	50,318	51,458
Student housing	1,349	1,510	1,125	1,027	1,623	1,609	1,622
Other residential buildings	734	761	720	663	747	748	766
Properties for commercial use	843	697	604	596	701	722	735
Residential institutions	756	1,046	516	602	745	842	988
Holiday houses	176	305	424	562	1,018	1,190	1,262
Unknown	23	27	681	1,034	-	-	-
Dwellings divided by area (dwelling size)							
Total	170,947	177,329	184,003	189,912	203,036	207,262	206,227
0–59 m^2	12,899	13,287	13,170	12,229	15,351	16,496	16,898
60–99 m^2	52,280	53,268	55,435	55,990	62,221	66,159	67,717
100–119 m^2	25,814	24,892	24,634	24,995	26,689	27,629	27,935
120–159 m^2	46,390	48,488	49,172	49,628	51,372	50,807	49,487
At least 160 m^2	33,564	37,394	40,930	46,059	47,404	46,171	44,189
Unknown	0	0	662	1,011	-	-	-
Dwellings divided by location (size of town)							
Total	170,947	177,329	184,003	189,912	203,036	207,262	206,227
Metropolitan area	0	0	499	0	0	0	0
City with at least 50,000 residents	0	0	1,424	0	0	0	0
City with 10,000–49,999 residents	62,695	65,653	71,728	78,109	85,588	88,912	89,480
City with 1,000–9,999 residents	51,392	54,016	51,024	55,364	59,414	60,469	60,932
City with less than 1,000 residents	56,860	57,660	55,873	56,439	58,034	57,881	55,814
Unknown	0	0	3,455	0	-	-	-

Sources: Statistics Denmark and own calculations.

Note: Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.

Table A.25. Number of persons, families and households in the Province of North Jutland, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Danish population by age							
Total	574,167	579,697	579,298	579,628	574,683	572,251	563,956
Children living at home	149,757	149,333	147,099	143,712	133,343	133,023	134,829
Adults up to 34 years old	113,929	107,444	98,085	94,721	95,763	91,882	87,468
Adults 35–64 years old	217,552	230,990	240,797	239,400	218,837	201,121	187,803
Adults 65–79 years old	69,428	67,613	67,768	75,452	96,942	101,204	102,060
Adults 80 years old or older	23,501	24,317	25,549	26,343	29,798	45,021	51,796
Number of families divided by couples and singles							
Total	276,820	280,991	283,874	289,120	297,620	299,842	296,437
Single men	58,721	60,477	63,746	68,291	74,503	77,489	79,240
Single women	70,510	71,139	71,805	74,033	79,397	82,967	84,507
Couples without children	74,945	78,936	81,896	82,947	85,237	82,020	75,594
Couples with children	72,644	70,439	66,427	63,849	58,483	57,366	57,096
Number of families divided by family size							
Total	276,820	280,991	283,874	289,120	297,620	299,842	296,437
1 person	116,108	118,632	121,470	127,261	138,971	145,630	148,650
2 persons	83,127	86,770	89,852	91,630	92,827	89,376	82,976
3 persons	32,805	30,619	28,494	27,574	27,385	26,056	25,201
4 persons	32,918	32,067	30,780	29,794	27,059	27,097	27,419
5 persons	9,860	10,579	10,832	10,541	9,231	9,471	9,790
6 or more persons	2,002	2,324	2,446	2,320	2,147	2,212	2,401
Number of families divided by couples and singles and number of children							
Total	276,820	280,991	283,874	289,120	297,620	299,842	296,437
Singles without children	116,108	118,632	121,470	127,261	138,971	145,630	148,650
Singles with 1 child	8,182	7,834	7,956	8,683	7,590	7,356	7,382
Singles with 2 children	3,947	3,967	4,667	4,860	5,411	5,552	5,687
Singles with 3 children	817	934	1,147	1,225	1,527	1,542	1,652
Singles with 4 or more children	177	249	311	295	322	303	293
Couples without children	74,945	78,936	81,896	82,947	85,316	82,093	75,677
Couples with 1 child	28,858	26,652	23,827	22,714	21,974	20,504	19,514
Couples with 2 children	32,101	31,133	29,633	28,569	25,532	25,555	25,767
Couples with 3 children	9,718	10,390	10,597	10,315	8,909	9,168	9,497
Couples with 4 or more children	1,967	2,264	2,370	2,251	2,068	2,139	2,318
Number of households							
Total	249,924	256,507	264,291	269,459	280,080	282,254	278,905
Number of families per household	1.108	1.095	1.074	1.073	1.063	1.062	1.063

Sources: *Statistics Denmark and own calculations.*

Note: *Data for year 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast.*

Table A.26. Number of dwellings in the Province of North Jutland divided by characteristics, selected years 1995–2040.

	1995	2000	2005	2010	2020	2030	2040
Dwellings divided by ownership and rental status (dwelling type)							
Total	249,924	256,507	264,291	269,459	280,080	282,254	278,905
Owner-occupied housing	155,940	160,998	158,577	158,177	157,837	154,374	148,150
Social housing	37,584	39,912	41,490	43,016	51,542	54,927	56,177
Cooperative housing	6,784	7,452	8,930	9,441	11,964	12,809	13,087
Publicly owned rented housing	4,337	4,544	4,244	4,839	6,330	7,853	9,177
Privately owned rented housing	39,514	42,608	45,818	47,365	52,407	52,292	52,314
Unknown	5,765	993	5,232	6,621	-	-	-
Dwellings divided by category (physical use of dwelling)							
Total	249,924	256,507	264,291	269,459	280,080	282,254	278,905
Farmhouses	25,835	23,820	22,803	21,254	19,030	17,019	15,264
Detached houses	127,388	131,776	133,375	135,471	136,597	134,859	130,322
Terraced houses	27,638	28,936	32,848	35,788	42,356	45,716	47,141
Multi-dwelling houses	63,261	65,700	68,747	70,306	74,914	77,028	78,286
Student housing	1,699	1,877	1,792	1,708	2,131	2,086	2,037
Other residential buildings	1,133	1,065	1,084	834	1,026	1,000	960
Properties for commercial use	1,169	971	861	805	940	913	958
Residential institutions	1,151	1,446	665	888	988	1,160	1,445
Holiday houses	626	867	951	1,348	2,098	2,474	2,492
Unknown	24	49	1,165	1,057	-	-	-
Dwellings divided by area (dwelling size)							
Total	249,924	256,507	264,291	269,459	280,080	282,254	278,905
0–59 m^2	22,739	23,538	23,437	22,381	24,645	25,395	26,157
60–99 m^2	82,994	83,333	85,928	86,946	93,455	97,513	99,225
100–119 m^2	38,137	37,021	36,463	36,086	38,920	39,717	39,764
120–159 m^2	61,873	64,077	65,183	65,624	66,199	65,010	62,139
At least 160 m^2	44,181	48,538	52,141	57,397	56,860	54,620	51,620
Unknown	0	0	1,139	1,025	-	-	-
Dwellings divided by location (size of town)							
Total	249,924	256,507	264,291	269,459	280,080	282,254	278,905
Metropolitan area	0	0	958	0	0	0	0
City with at least 50,000 residents	59,460	61,329	50,596	54,514	58,203	59,898	60,622
City with 10,000–49,999 residents	43,614	44,956	50,732	53,246	56,353	57,737	58,691
City with 1,000–9,999 residents	65,902	69,088	77,400	83,193	88,752	90,228	89,094
City with less than 1,000 residents	80,948	81,134	78,971	78,506	76,772	74,391	70,499
Unknown	0	0	5,634	0	-	-	-

Sources: Statistics Denmark and own calculations.

Note: Data for 1995–2010 are historical data, while data for year 2020 and the following years are in the forecast. I the forecast we remove dwellings with one or more unknown characteristic. These unspecified characteristics are distributed on known values. There are thus no dwellings with unknown characteristics in the forecast.

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