

DREAM

Danish Research Institute for  
Economic Analysis and Modelling



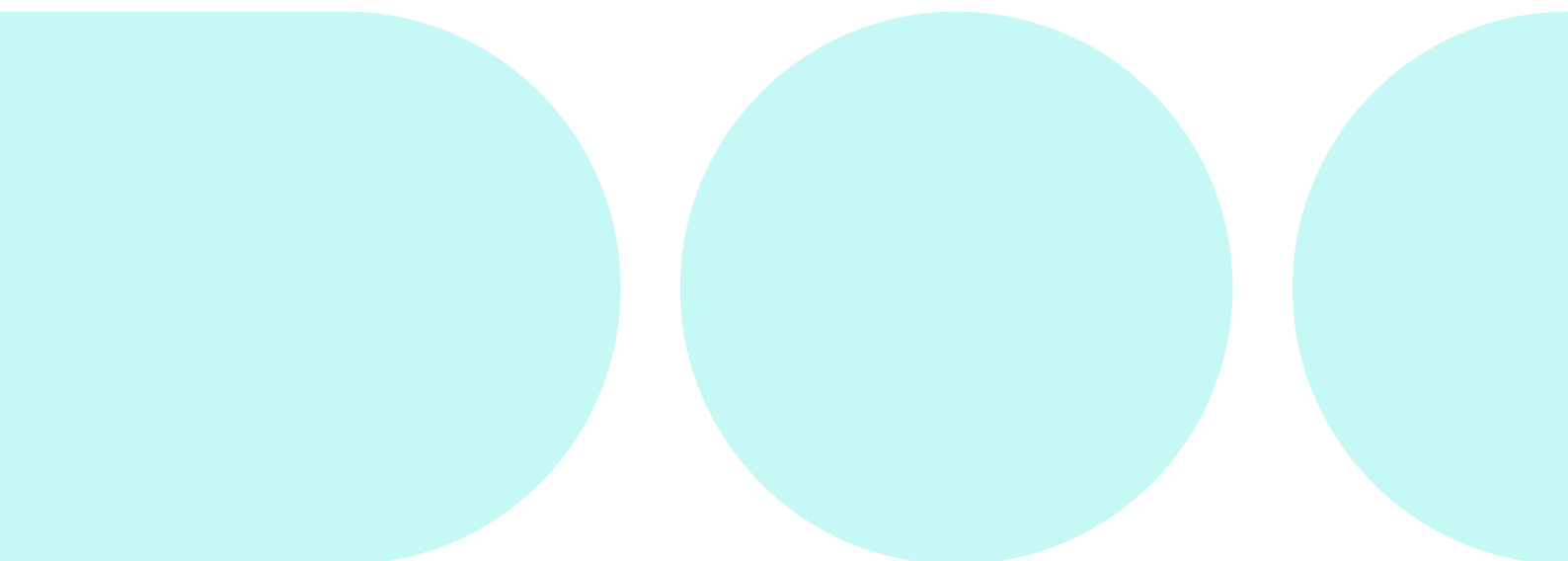
# The creation of lifecycle profiles for households in MAKRO

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**Model documentation**

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# Preface

This is the documentation for the creation of household lifecycle profiles for use in MAKRO. The profiles are used in determining key parameters affecting the behavior of households over time when the model is used for forecasting. The profiles are based on data from the Lovmodel database, Statistics Denmark's wealth data, and the national accounts.

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# 1 Introduction

The households in MAKRO are based on an OLG structure with 100 age groups. Therefore, it is a requirement of the data set used to calibrate households that it contains data distributed across age groups. The task that MAKRO will be used for also requires that the sum of the lifecycle profiles over age correspond to the totals found in the national accounts. Such a dataset was not available prior to the creation of the MAKRO lifecycle profiles. Additionally, danish administrative data does not contain consumption data. A consumption profile is therefore imputed.

The administrative data used to create the lifecycle profiles is drawn from the Lovmodel database. However, the definitions of variables of interest might differ between Lovmodel and MAKRO, which use the definitions from the national accounts. An example could be the definition of wages, which in MAKRO also contains income from self-employed. The first step is, therefore, to create a correspondence between Lovmodel variables and MAKRO variables. This step is described in Section 2. The second step is to impute a consumption profile. Given that income and wealth variables have been defined in a way that is consistent with the theoretical framework of MAKRO, the budget constraint from the model can be used for imputation. The imputation is described in Section 3. Even though the definitions of the created life cycle profiles then match that of the national accounts, the sum of profiles will still not match the totals from the national accounts. This due to differences in the collection of data and the level of detail in the two databases. Therefore, the third step consists of scaling the created profiles to fit the national accounts. For most of the profiles, this amounts to scaling profiles by a constant factor, but for some variables, the procedure is more involved. The scaling to national accounts is described in Section 4. Note that in the current version, totals from the ADAM database are used as the national accounts totals. Since ADAM is consistent with the national accounts, this is a valid approach.

## 2 Correspondance between microdata and lifecycle profiles

For an overview of the data used from the Lovmodel database, and the creation of auxiliary variables not normally found in the Lovmodel database, see J.nr. 2019-6655.

### 2.1 Wages

The total value of wages received by each working member of age group  $a$  at time  $t$  is denoted  $vW_{a,t}$  in MAKRO. This includes all types of remuneration of labor for domestic households, including actual paid wages, employer-paid pensions, and firm profits paid as wages for self-employed. In LOVMODEL, actual wages paid to domestic households are denoted  $PI1LN_{a,t}$ , profits paid as wages for self-employed are denoted  $PI2_{a,t}$ , and certain special types of labor income, i.e., from freelancing without doing it through your own firm, are denoted  $PI4_{a,t}$ . Total payments to pension funds are denoted  $vPensIndb_{a,t}$  in MAKRO. However, these include individual payments made to pension funds, which are not a form of remuneration of labor. These payments are fully deductible, and the tax deduction is denoted  $FR1_{a,t}$  in Lovmodel. Furthermore, unemployed receive a government-paid contribution to the mandatory pension fund, ATP. This transfer is denoted  $OI5_{a,t}$  in LOVMODEL. Employer-paid pension contributions are therefore given by  $vPensIndb_{a,t} - FR1_{a,t} - OI5_{a,t}$ . The value of wages received by working members of each age group is therefore given by

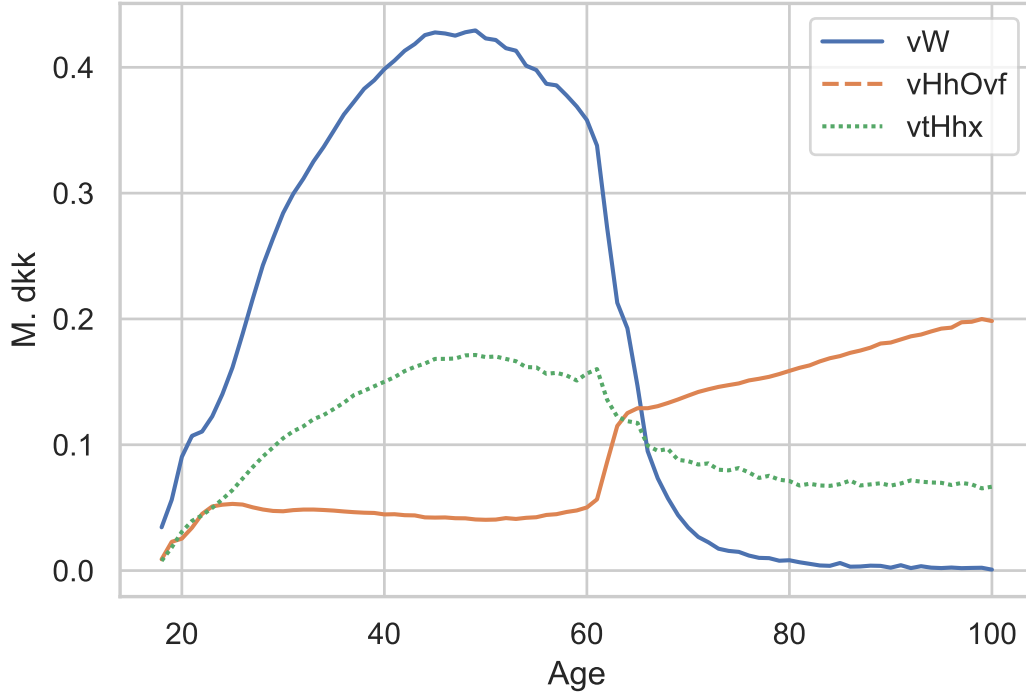
$$vW_{a,t} = PI1LN_{a,t} + PI2_{a,t} + PI4_{a,t} + (vPensIndb_{a,t} - FR1_{a,t} - OI5_{a,t})$$

The result is the wage profile shown in Figure 2.1.

### 2.2 Transfers

Transfers received by each individual of age group  $a$  at time  $t$  is denoted  $vOvf_{a,t}$  in MAKRO. They include all types of transfers paid by the government to households.

Figure 2.1: Wage, Transfer and Tax profiles



The figure shows profiles based on data from DST. All profiles are for 2016.

They are closely related to the total transfers in LOVMODEL denoted  $OVER_{a,t}$ . However, transfers in MAKRO also include a few additional components. The first is a government-paid contribution to the mandatory pension fund, ATP, to unemployed denoted  $OI5_{a,t}$ . Second they also include unemployment insurance when sick (Sygedagpenge) which is denoted by  $PI1SY_{a,t}$ . Furthermore, payments for “Tjenestemandspension”  $QTJPENS_{a,t}$  and the Grøncheck tax deduction  $SK4_{a,t}$  are also considered transfers. Transfers in MAKRO are therefore given by

$$vOvf_{a,t} = OVER_{a,t} + OI5_{a,t} + PI1SY_{a,t} + QTJPENS_{a,t} + SK4_{a,t}$$

The resulting profile is shown in Figure 2.1.

## 2.3 Taxes

Total income taxes paid by each individual of age group  $a$  at time  $t$  is denoted  $vtHhx_{a,t}$  in MAKRO. These include all types of wage taxes in addition to certain other taxes. However, they do not include taxes on real estate. The amount paid in taxes for different wage taxes are denoted,  $vtHhAM_{a,t}$ ,  $vtBund_{a,t}$ ,  $vtTop_{a,t}$  and  $vtKommune_{a,t}$ . They map to the LOVMODEL variables as

$$\begin{aligned} vtHhAM_{a,t} &= SK1_{a,t}, & vtBund_{a,t} &= SK2SB_{a,t} + SK2SM_{a,t}, \\ vtTop_{a,t} &= SK2ST_{a,t}, & vtKommune_{a,t} &= SK2K_{a,t} \end{aligned}$$

Church tax (Kirkeskat) is denoted  $vtKirke_{a,t}$  in MAKRO and maps directly to  $SK2KI_{a,t}$  in LOVMODEL. Taxes on stock earnings are denoted  $vtAktie_{a,t}$  and are directly mapped to lovmodel:

$$vtAktie_{a,t} = QAKTSKA_{a,t}$$

No age profile exists for media tax (Medielicens) denoted  $vtMediaSats_{a,t}$  in MAKRO. Since the media tax is fixed payment for all adults who own a TV, computer or cellphone, it is simply imputed as a lump sum tax on all adults. This is done by dividing the total amount paid denoted  $sym_t$  with the total number of persons in the working age, drawn from BFR and here denoted by  $\sum_{a=15}^{100} nPop_{a,t}$ . A unit correction is done by dividing with 1000. We, therefore, have that

$$vtMediaSats_{a,t} = \frac{'sym'_t}{1000 \sum_{a=15}^{100} nPop_{a,t}}.$$

Road taxes (Vægtafgift) are denoted  $vtHhVaegt_{a,t}$  in MAKRO, and mapped to Lovmodel as

$$vtHhVaegt_{a,t} = AfgGrup1_{a,t} + AfgGrup2_{a,t} + AfgGrup3_{a,t} + AfgGrup4_{a,t}$$

The variables named  $AfgGrupx_{a,t}$  correspond to “Vægtafgift”, “Udligningsafgift”, “Grøn Ejerafgift” and “Grøn udligningsudgift”, respectively. Mandatory social contributions

(Bidrag til sociale ordninger) are denoted  $vBidrag_{a,t}$  in MAKRO. No age profile is available, so instead an average rate of contributions out of wages is imputed using aggregate data and applied on wages. The imputed rate is given by the aggregate contributions denoted  $'tp\_h\_o'_t$  in the ADAM database divided by the aggregate wages of employed denoted  $'Yw'_t - 'Ywn\_e'_t$ . Individual contributions are therefore given by

$$vBidrag_{a,t} = \frac{'tp\_h\_o'_t}{'Yw'_t - 'Ywn\_e'_t} vW_{a,t} \frac{nBesk_{a,t}}{nPop_{a,t}}$$

where  $\frac{nBesk_{a,t}}{nPop_{a,t}}$  is converting from contributions per employed in age group to per person in age group. Additionally, taxes by individually owned businesses are also included in the taxes paid by households and is denoted  $vtVirksomhed_{a,t}$ . These taxes are directly mapped lovmodel as

$$vtVirksomhed_{a,t} = NETTOVIRK_{a,t}$$

Additional fees on pensions being withdrawn are denoted  $vtPersrest_{a,t}$ . These correspond to the fees denoted as  $FBptp41_{a,t}$ ,  $FBptp42_{a,t}$ ,  $FBptp44_{a,t}$  and  $FBptp67_{a,t}$  in Lovmodel. However, in the national accounts fees from pensions withdrawn from Danish citizens living abroad and fees from pensions withdrawn to the death of the receiver are also included. The final mapping is therefore given by

$$vtPersrest_{a,t} = FBptp41_{a,t} + FBptp42_{a,t} + FBptp44_{a,t} + FBptp67_{a,t} \\ + (UDkptp41_{a,t} + UDkptp42_{a,t} + UDkptp44_{a,t} + UDkptp67_{a,t}) \frac{nUDkptp_{a,t}}{nFBkptp_{a,t}}$$

where the term  $\frac{nUDkptp_{a,t}}{nFBkptp_{a,t}}$  corrects for the fact that  $UDkptp_x$  is measured as fees paid per person who has either died this period or is situated abroad. This mapping simply amounts to assuming that all the fees are paid by people living in Denmark. This will probably change in the future.

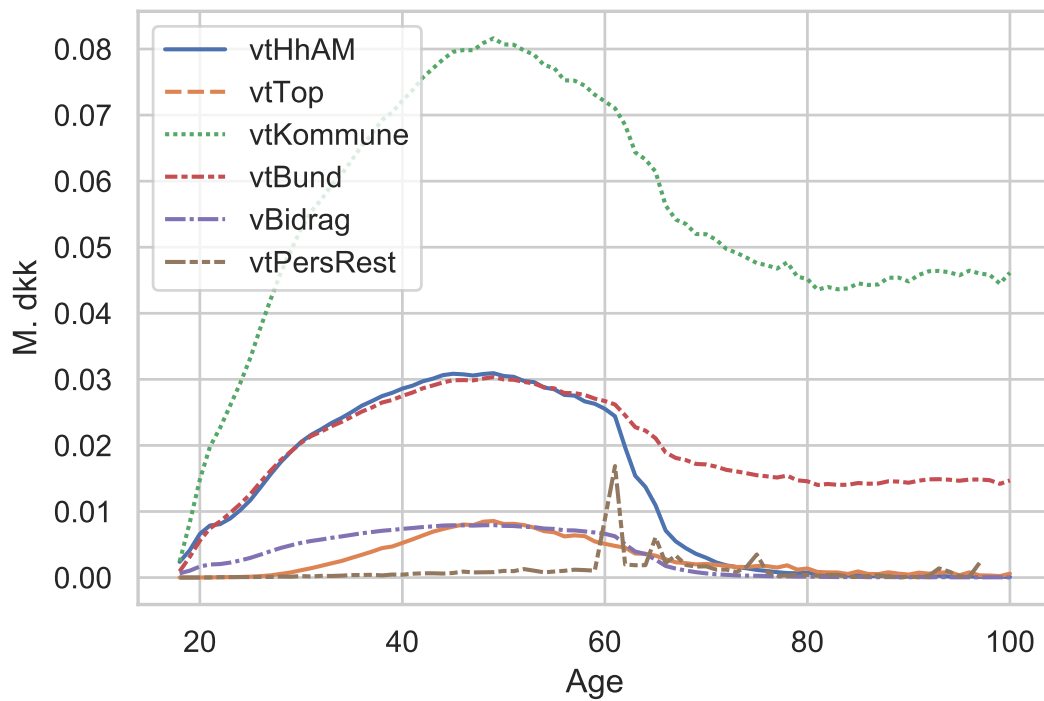


Finally, taxes paid by household can be defined as

$$\begin{aligned}
 vtHhx_{a,t} = & vtHhBund_{a,t} \\
 & + vtHhAM_{a,t} + vtKommune_{a,t} \\
 & + vtTop_{a,t} + vtVirksomhed_{a,t} \\
 & + vtKirke_{a,t} + vtAktie_{a,t} \\
 & + vtHhVaegt_{a,t} + vtMediesats_{a,t} \\
 & + vBidrag_{a,t} + vtPersrest_{a,t}
 \end{aligned}$$

The tax profile is shown in Figure 2.1, and the profiles for its sub-components are shown in Figure 2.2.

Figure 2.2: Tax type profiles

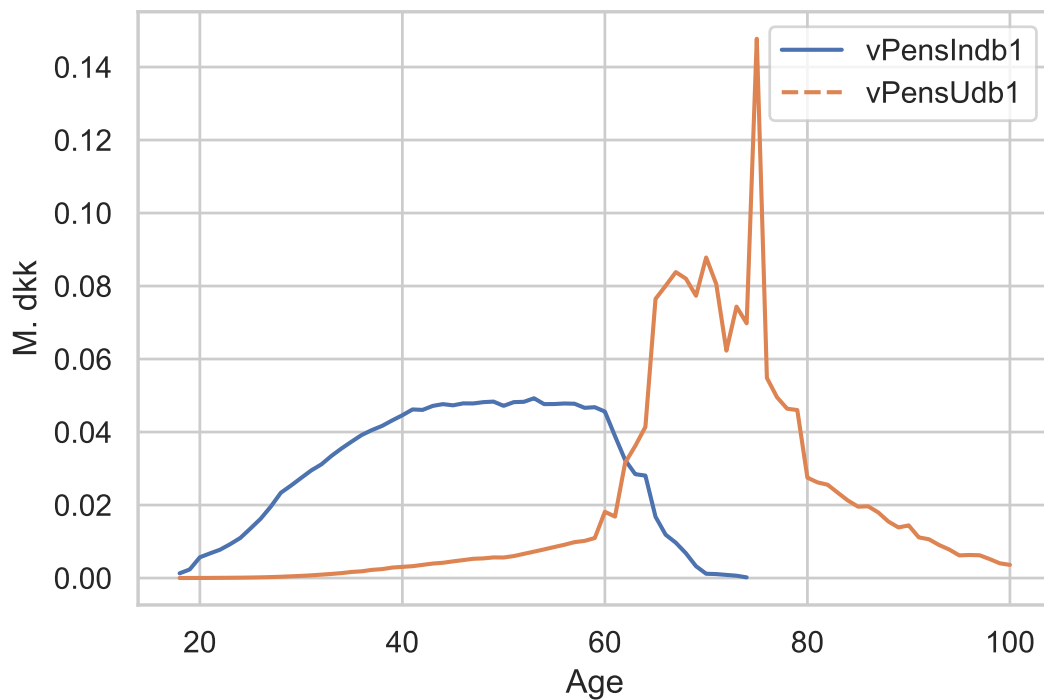


The profiles shown are based on data from DST. All profiles are for 2016.

## 2.4 Pension contributions and income

Contributions pensions are denoted  $vPensIndb_{a,t}$  in MAKRO. They contain all pension contributions, including those paid by an employer, by the government, and those paid by the individual to a private pension fund. These are drawn from the DREAM PENSION data. Likewise, Pension payments from pension funds are denoted  $vPensUdb_{a,t}$  in MAKRO. They include all payments from the pension funds contributed to in  $vPensIndb_{a,t}$ , and are also drawn from the DREAM PENSION data. Pension contributions and payments are shown in Figure 2.3.

Figure 2.3: Tax type profiles



*The profiles shown are based on data from DST. All profiles are for 2016.*

## 2.5 Assets and Liabilities

In MAKRO the value of housing assets owned by each individual of age group  $a$  at time  $t$  is denoted  $vBolg_{a,t}$ . It includes all types of housing used for residential purposes by the owner. It, therefore, excludes privately-owned housing rented out by the owner. This amounts to the following variables in FORMUE:  $A.1$  Full-year residential housing, Full ownership, (Ejerbolig),  $A.2$  Full-year residential housing, Cooperative ownership, (Andelsbolig) and  $A.3$  Part-time residential housing. Housing in MAKRO is therefore given by

$$vBolg_{a,t} = A.1_{a,t} + A.2_{a,t} + A.3_{a,t}$$

Cash deposits in Banks owned by households are denoted  $vHh_{a,t}^{Bank}$  in MAKRO. It includes actual cash deposits denoted  $B.1$  in FORMUE and mortgage deeds in deposit (Pantebreve i depot)  $B.5$ ,

$$vHh_{a,t}^{Bank} = B.1_{a,t} + B.5_{a,t}$$

Bonds owned by households are denoted  $vHh_{a,t}^{Obl}$  in MAKRO. They correspond directly to  $B.2$  in FORMUE,

$$vHh_{a,t}^{Obl} = B.2_{a,t}$$

Domestic and Foreign stocks are denoted  $vHh_{a,t}^{IndlAkiter}$  and  $vHh_{a,t}^{UdlAkiter}$  respectively. The FORMUE data does not contain subtotal for domestic and foreign stocks. The total amount of stocks owned in the FORMUE corresponds to the sum of privately owned stocks and owned shares in investment funds, denoted  $B.3$  and  $B.4$ , respectively. LOVMODEL does, however, include age profiles for domestic and foreign stocks denoted  $AKT\_AKTIE_{a,t}$  and  $AKT\_AKTIE\_UD_{a,t}$ . Using the implied ratio of domestic and foreign stocks from LOVMODEL the total value of owned stock from FORMUE is distributed in the following way

$$vHh_{a,t}^{InlAkiter} = \frac{AKT\_AKTIE_{a,t}}{AKT\_AKTIE_{a,t} + AKT\_AKTIE\_UD_{a,t}} \quad (B.3 + B.4)$$

and

$$vHh_{a,t}^{UdlAkiter} = \frac{AKT\_AKTIE\_UD_{a,t}}{AKT\_AKTIE_{a,t} + AKT\_AKTIE\_UD_{a,t}} \quad (B.3 + B.4)$$

Two types of liabilities for households exist in MAKRO, Mortgages and Bank debt. Mortgages,  $vHh_{a,t}^{RealKred}$ , maps directly to  $E.1$  in Lovmodel,

$$vHh_{a,t}^{RealKred} = E.1_{a,t}$$

Bank debt,  $vHh_{a,t}^{Bankgaeld}$  is then residual determined as all non-mortgage debt

$$vHh_{a,t}^{Bankgaeld} = E_{a,t} - E.1_{a,t} + F_{a,t}$$

This means that  $vHh_{a,t}^{Bankgaeld}$  also contains other types of debt such as student debt (SU-Lån) and other types of debt owed to the public sector.

Net financial assets, excluding mortgages and pensions, are then given by

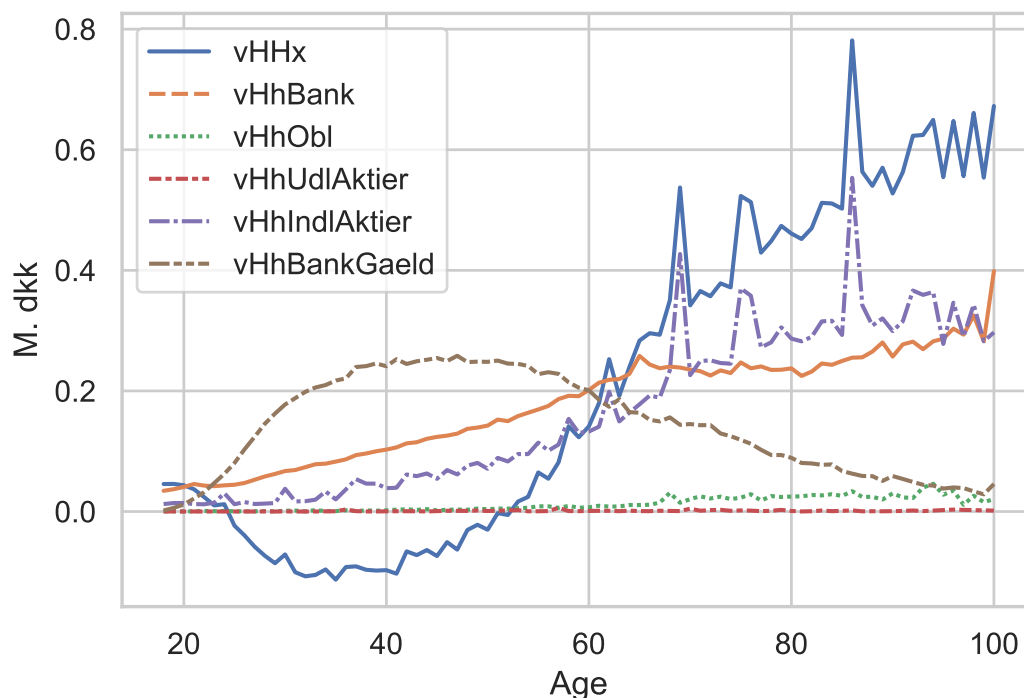
$$\begin{aligned} vHHx_{a,t} &= vHh_{a,t}^{InlAkiter} + vHh_{a,t}^{UdlAkiter} \\ &+ vHh_{a,t}^{Obl} + vHh_{a,t}^{Bankgaeld} - vHh_{a,t}^{Bankgaeld} \end{aligned}$$

Figure 2.4 shows the profiles for all financial assets and liabilities, while the profiles for real estate and mortgages are shown in Figure 2.5.

## 2.6 Returns to assets and liabilities

Returns in MAKRO are different for each asset type but the same for each age group. Returns for each asset type of financial asset and liability is also divided into interests and capital gains. Differences in portfolio composition, therefore, drive differences in returns across age groups. The Lovmodel database contains separate returns for real estate, mortgages, and combined financial assets. However, these do not contain

Figure 2.4: Financial assets type profiles

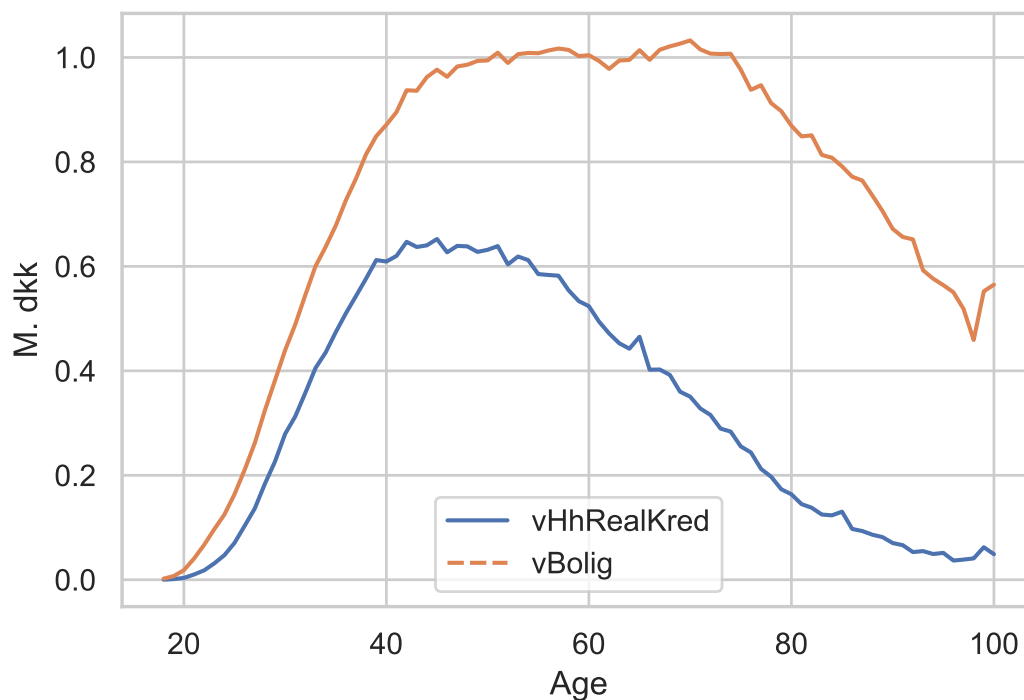


*The profiles shown are based on data from DST. All profiles are for 2016.*

capital gains. Furthermore, some types of costs, such as a range of fees related to mortgages (Bidragssydelsler), are defined as interests in Lovmodel but as consumption of financial services in the National accounts. Instead of using returns from Lovmodel, returns calculated based on the national accounts are used. This method has several advantages. It makes it possible to take capital gains on financial assets into account, in the same way as much of the literature on consumption imputation such as Abildgren et al. [2018] and Fagereng and Halvorsen [2015]. Browning and Leth-Petersen [2003] also find that ignoring capital gain results in the imputed consumption being too low.<sup>1</sup>. Another advantage is that this results in a measure of mortgage interest that does not include the mentioned fees and is consistent with the definition of mortgage interests in the national accounts. Another minor advantage is that the profiles for returns will

<sup>1</sup>This result is dependent on the sign of the capital gains

Figure 2.5: Real estate and mortgage profiles



*The profiles shown are based on data from DST. All profiles are for 2016.*

be directly applicable in MAKRO since variations in returns across age groups only are driven by differences in portfolio composition.

The ADAM database contains data on capital gains and interests for most asset types. Unfortunately, these are market rates and do not necessarily coincide with the rates relevant to households. However, ADAM contains the flow of returns to the households distributed across asset types. In practice, this means that return rates are calculated as the total flow of interests or capital gains from each asset type in ADAM divided by the total stock of that asset in ADAM. The definition for each asset type can be seen below. Note that variables of the surrounded by " are flows from ADAM and use different notation compared to Lovmodel and MAKRO. They are also measured in millions dkk. compared to billions dkk. in MAKRO. A unit correction factor of 1/1000

is therefore included in the definitions:

$$rOmv_t^{InlAktier} = \frac{'Owsr\_d\_h'_t/1000}{vHh_{aTot,t-1}^{InlAkiter}}$$

$$rOmv_t^{UdlAktier} = \frac{'Owsr\_e\_h'_t/1000}{vHh_{aTot,t-1}^{UdlAkiter}}$$

$$rOmv_t^{Obl} = \frac{'Ownbr\_h'_t/1000}{vHh_{aTot,t-1}^{InlAkiter}}$$

$$rOmv_t^{RealKred} = \frac{('bowbm'_t * 'Wlm\_h\_cf'_t + 'JDWlm\_h\_cf'_t) / 1000}{vHh_{aTot,t-1}^{Realkred}}$$

$$rOmv_t^{Bank} = \frac{'JDWnq\_h'_t/1000}{vHh_{aTot,t-1}^{Bank} + vHh_{aTot,t-1}^{Bankgaeld}}$$

$$rOmv_t^{Bankgaeld} = -\frac{'JDWnq\_h'_t/1000}{vHh_{aTot,t-1}^{Bank} + vHh_{aTot,t-1}^{Bankgaeld}}$$

Capital gains for bank deposits and bank debt might seem strange, but it contains revaluations such debt settlements. The ADAM database only contains the revaluations for net bank deposit/debt,  $'JDWnq\_h'_t$ . It is assumed that these are evenly distributed across deposits and debt, i.e., the rates are the same, but with different signs. Interests from stocks are defined similarly. Interest from stocks is primarily dividends. The ADAM database only contains the total flow of interest paid by households from domestic and foreign stocks. The rate is therefore assumed to identical:

$$rRente_t^{InlAktier} = \frac{'Tiu\_z\_h'_t/1000}{vHh_{aTot,t-1}^{InlAkiter} + vHh_{aTot,t-1}^{UdlAkiter}}$$

$$rRente_t^{UdlAktier} = \frac{'Tiu\_z\_h'_t/1000}{vHh_{aTot,t-1}^{InlAkiter} + vHh_{aTot,t-1}^{UdlAkiter}}$$

Unfortunately, the ADAM database only contains the total flow of interest to household, i.e., the sum of interests from bank debt/deposits, bonds, and mortgages <sup>2</sup>. It is assumed that the household rate for bank debt/deposits and bond is identical to the market rate. The household interest rate for mortgages is then determined residually.

$$\begin{aligned} rRente_t^{Obl} &= 'iwbz'_t \\ rRente_t^{Bankgaeld} &= 'iwmm'_t \\ rRente_t^{Bank} &= 'iwmm'_t \end{aligned}$$

With all rates of interest and capital gains defined, the returns on financial assets are calculated based on each age groups portfolio composition

$$vHhAfk_{a,t} = \sum_p (rRente_t^p + rOmv_t^p) vHh_{a-1,t-1}^p$$

where  $p$  is an index containing the different financial asset types, i.e., Bank debt/deposits, bonds, and stocks. The resulting profiles for returns on financial assets, excluding mortgages and pensions, are seen in Figure 2.6. Since these fluctuate quite markedly, profiles from 2015-2017 are shown. Note how the profile is different in 2016 compared to 2015 and 2017. This is caused by the negative return on stocks and differences in portfolio composition.

## 2.7 Real estate costs and returns

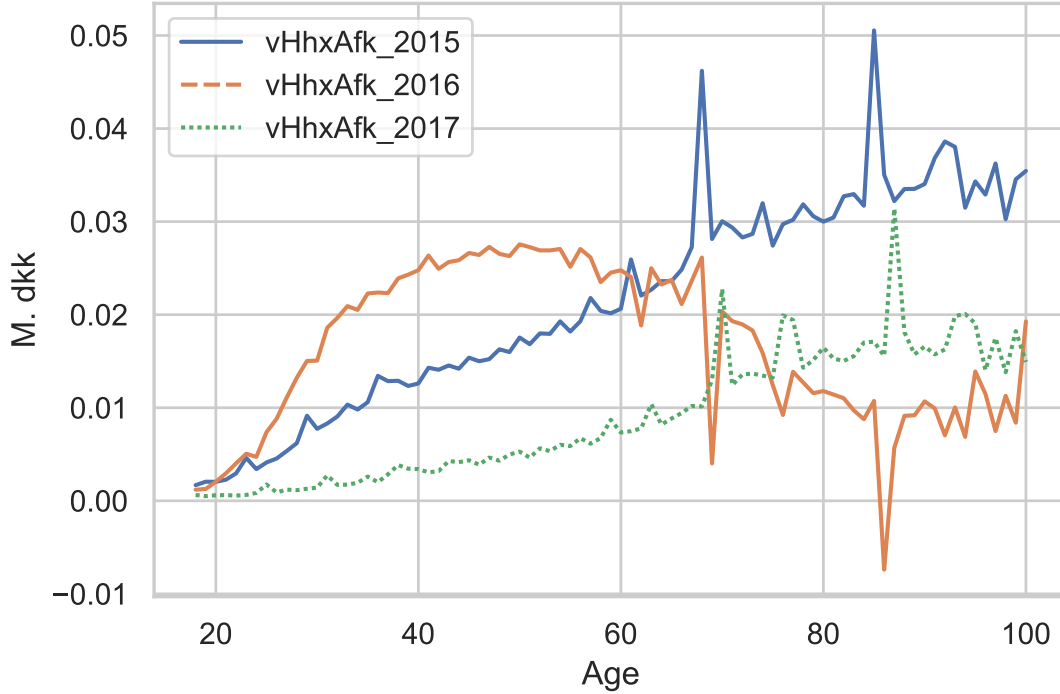
In MAKRO the variable  $vBoligUdgift_{a,t}$  contains all costs and returns related to owning and acquiring real estate. Some of these are covered by administrative data

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<sup>2</sup>Technically interests from private pensions are also included in this total flow of interests, but these are covered by data and can simply be subtracted from the total



Figure 2.6: Financial assets return profiles



*The profiles shown are based on data from DST.*

such as real estate taxes. For other elements, only aggregate data exists and these must be distributed across age group using different methods.

One of these is the return on real estate from changes in real estate prices. It is assumed that the average rate of return for real estate is the same for all age groups. Note, that this is a weaker assumption than assuming that all individuals experience the same returns. The cost of acquiring new real estate net the return of real estate and changes in mortgage debt is therefore given by

$$\left( vBolg_{a,t} - \frac{vBolg_{aTot,t}}{vBolg_{aTot,t-1}} vBolg_{a-1,t-1} \right) - \left( vHh_{a,t}^{RealKred} - vHh_{a-1,t-1}^{RealKred} \right)$$

Note, that if an no new housing is constructed and an age group does not buy or sell housing

$$\left( vBolg_{a,t} - \frac{vBolg_{aTot,t}}{vBolg_{aTot,t-1}} vBolg_{a-1,t-1} \right) = 0$$

The variable  $vBoligOmx_{a,t}$  contains all other costs related to owning real estate. These include interest on mortgage debt, real estate taxes, investment in new real estate capital and maintenance. Real estate taxes are mapped from Lovmodel,

$$vtEjd_{a,t} = SKEV_{a,t}$$

The cost of mortgage debt is simply calculated using the variables defined in Sections 2.5 and 2.6

$$\left( rRente_t^{RealKred} + rOmv_t^{RealKred} \right) vHh_{a-1,t-1}^{RealKred}$$

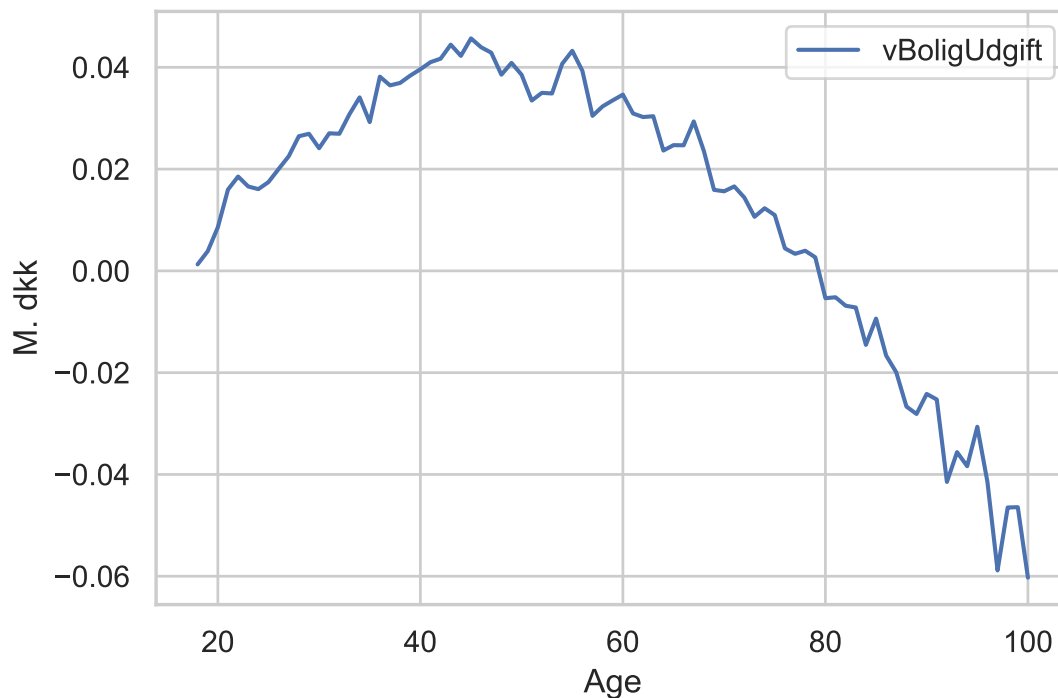
Maintenance and a number of other technical costs related to real estate are contained in the rate  $rBoligOmkrest_t$ . This rate is calculated as the flow divided by the total stock of housing. It is assumed that the rate is equal across all age groups so that the profile for maintenance cost is determined by the amount of housing owned by each age group. The same method is used to create the profile for the cost of investing in new housing capital. Here it is important to note that investment is construction and not acquisition. Actual housing accumulation for an age group is determined by the real estate profiles described in Section 2.5.

$vBoligUdgift_{a,t}$  contains all costs from  $vBoligOmx_{a,t}$  in addition to the return on real estate and the cost acquiring new real estate,

$$\begin{aligned} vBoligUdgift_{a,t} &= vBoligOmx_{a,t} \\ &+ \left( vBolig_{a,t} - \frac{vBolig_{aTot,t}}{vBolig_{aTot,t-1}} vBolig_{a-1,t-1} \right) \\ &- \left( vHh_{a,t}^{RealKred} - vHh_{a-1,t-1}^{RealKred} \right) \end{aligned}$$

The resulting profile can be seen in Figure 2.7. It might seem like a strong assumption that investments and construction are proportional to owned real estate. One might suspect that while older age groups will tend to have a larger stock of housing, they will not invest in additional construction. However, it is important to remember that increases in the total value of real estate due to additional construction is included in  $\frac{vBolig_{aTot,t}}{vBolig_{aTot,t-1}}$ . Therefore, this assumption only results in imputation error for consumption, if the pass through of construction to real estate value varies across age groups.

Figure 2.7: Costs and returns of Real Estate



*The profiles shown are based on data from DST. All profiles are for 2016.*

## 2.8 Bequests

No age profiles exist for bequests received in danish administrative data. Bequest profiles must therefore be created. This is done using a bequest distribution matrix<sup>3</sup>. First, the average bequest from a person of age  $a$  to a person of age  $A$ ,  $H_{a,A,t}$ , is estimated using the approach from Boserup et al. [2016]. The average bequests from a person of age  $a$  is then given by

$$H_{a,t} = \sum_A H_{a,A,t} nPop_{A,t}$$

<sup>3</sup>The code for the creation of the bequest distribution matrix can be found in the model folder under 'Data\Lovmodel \Bequests.R'

These are averaged over time, and the share of a  $a$  year olds bequest going to a specific  $A$  year old is then calculated as

$$\chi_{a,A} = \frac{H_{a,A}}{H_a}$$

These are then smoothed using a local linear regression with a Gaussian kernel. Since  $\chi_{a,A}$  is time invariant,  $\sum_A \chi_{a,A} nPop_{A,t}$  will generally not sum to 1. This means that bequests given will not be same as bequests received. To prevent this, the shares are normalized in the following way

$$D_{a,A,t} = \frac{\chi_{a,A}}{\sum_A H_{a,A,t} nPop_{A,t}}$$

These share do have the desired property that

$$\sum_A D_{a,A,t} nPop_{A,t} = \frac{\sum_A \chi_{a,A} nPop_{A,t}}{\sum_A H_{a,A,t} nPop_{A,t}} = 1$$

$D_{a,A,t}$ , therefore, describes how bequests are distributed. An example of the distribution of bequests from 70-year-olds can be seen in Figure 2.8.

The actual bequest given by a dead person,  $vArvgivet_{a,t}$ , is assumed to the persons net wealth and the returns of that wealth

$$vArvgivet_{a,t} = vHhx_{a-1,t-1} + vBolig_{a-1,t-1} - vHh_{a-1,t-1}^{RealKred} + vHhxAfk_{a,t} - vBoligOmkk_{a,t}$$

It is therefore assumed that the wealth of the average person who dies at age  $a$  is equivalent to the average wealth of a person who survives at age  $a$ . This might be a strong assumption, and it is planned that this framework is extended to handle different levels of wealth for persons who die and persons who survive.

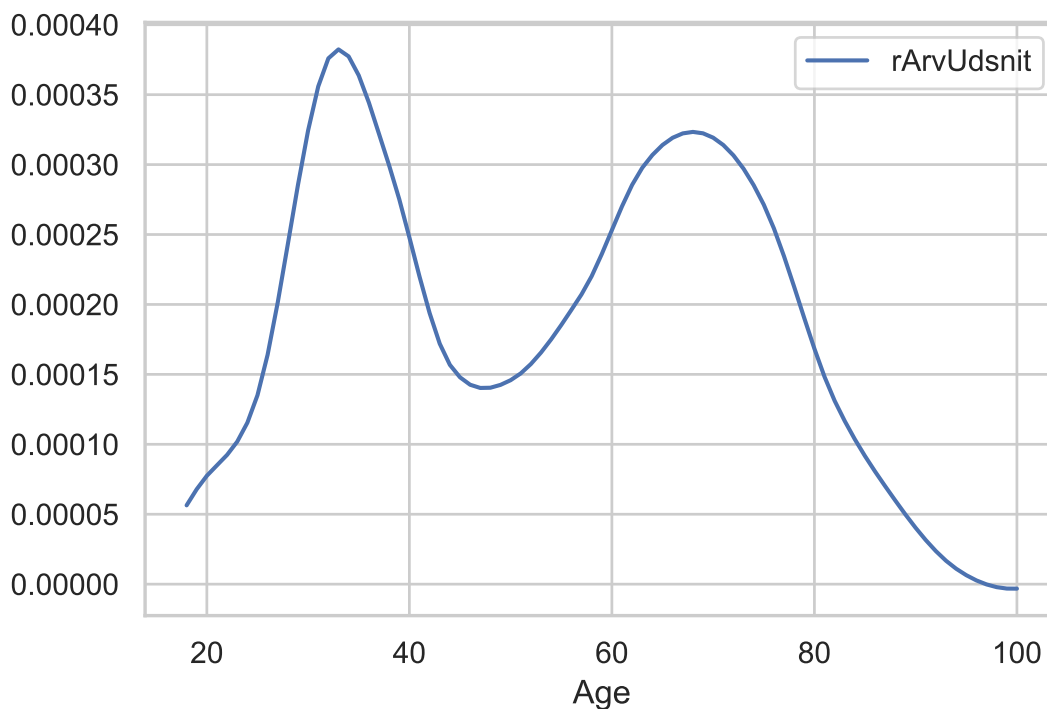
Bequest received,  $vArv_{a,t}$  can then be calculated using the distribution matrix,

$$Arv_{A,t} = \sum_a D_{a,A,t} vArvgivet_{a,t} \psi_{a-1,t-1} * nPop_{a-1,t-1}$$

where  $\psi_{a-1,t-1}$  is the share of a  $a - 1$  year olds dying in period  $t - 1$ .

Figure 2.9 shows the age profile of received bequests.

Figure 2.8: Receiver distribution for bequests given by 75 year old.

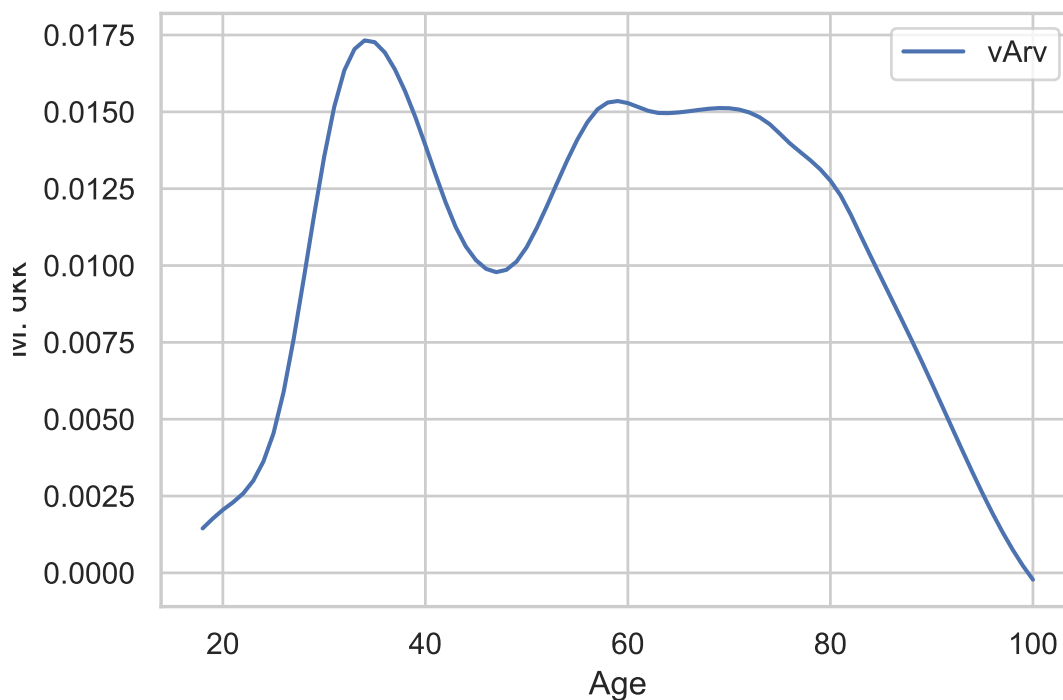


*The profile is generated according to the procedure described in Section 2.8. Profile is for 2016.*

### 3 Imputation of consumption

Since no administrative data for consumption exists, the consumption profile has to be imputed. This will be done using the budget constraint from MAKRO. Technically the consumption profile can either be imputed before or after the other profiles have been scaled to match the national accounts. Here it is done before as it has several advantages. The main reason is that imputing after scaling is equivalent to including all 'scaling noise' in the consumption profile. As can be seen in Section A.1, this would result in a profile without any credibility. Another reason is that the budget constraint in MAKRO contains the variable  $vHhNFErest_t$ , which purely there for technical accounting reasons. This includes government transfers to NGOs. When imputing before scaling this post can be omitted from the budget constraint.

Figure 2.9: Bequests received



*The profile shown is based on data from DST and the bequest distribution matrix described in Section 2.8. Profile is for 2016.*

The budget constraint in MAKRO also includes a correction term that implements the assumption that persons who die are, on average, as wealthy as the ones who survive from the same age group. Furthermore, the correction also implements the assumption that persons who immigrate and emigrate have no wealth. However, it is possible to impute consumption without invoking this assumption. Instead, lagged versions of stock variables are created based on samples that only contain persons present in the current period. Persons who have died or emigrated in the meantime are therefore not included. An example could be that a lagged version of  $vHh x_{a,t}$  is created called  $vHh x_{a,t}^L$ .  $vHh x_{a,t}^L$  is based on the same persons used to create  $vHh x_{a,t}$ , and is therefore different from  $vHh x_{a-1,t-1}$ . Since  $vHh x_{a,t}$  and  $vHh x_{a,t}^L$  are based on the exact same sample of persons, a correction is no longer needed when calculating

the change  $vHhx_{a,t} - vHhx_{a,t}^L$ . These lagged variables are then used in place of all regular variables with lags defined in Section 2. Other papers such as Abildgren et al. [2018] make additional exclusions from the sample, such as removing people who sold or bought real estate. The reason for this is that it removes certain parts of the budget constraint that is not covered by administrative data. This exclusion, along with several others, is thoroughly studied as a robustness check in Appendix A.3. Generally, they change very little, and the subgroups are therefore not excluded.

The budget constraint used to impute a consumption profile is

$$\begin{aligned}
vC_{a,t} = & \left( vHHx_{a,t}^L + vHhx_{a,t}Af_{a,t} \right) - vHHx_{a,t} \\
& + vW_{a,t} + vOvf_{a,t} - vtHhx_{a,t} \\
& + vPensUdb_{a,t} - vPensindb_{a,t} \\
& - vBoligUdgift_{a,t} + vARV_{a,t}
\end{aligned}$$

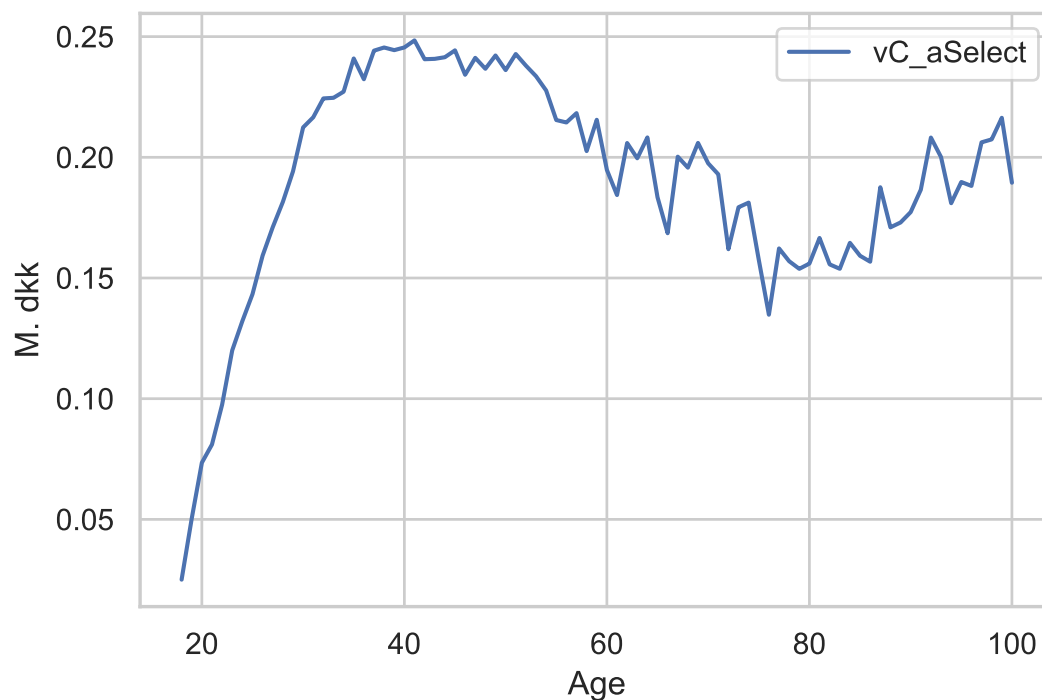
The resulting imputed consumption profile is shown in Figure 3.1.

## 4 Scaling to national accounts

### 4.1 Scaling procedure

Even though the profiles have been constructed in a way that is consistent with the national accounts, the profiles will not match the totals from the ADAM database perfectly. This is due to differences in the data collection and the level of detail in the databases. Table 1 shows the relative difference between the sum of a constructed profile and the corresponding total from the ADAM database. The fit is generally good, but some total ratios are extreme and require a comment. The group of variables with the worst correspondence between the created variables and ADAM is clearly the wealth variables, especially stocks. The reason is that a number of asset types are not included in administrative data but are included in aggregate data. This is primarily non-public stocks. When scaling, it will be assumed these are distributed similarly

Figure 3.1: Imputed Consumption profile



*The profile shown is based on data from DST. Profile is for 2016.*

to public stocks. Data on the distribution of non-public stocks is scarce, and it is, therefore, hard to judge whether this is a valid assumption. Since the return profiles are driven by the portfolio composition and size, the fit of returns is also fairly poor. The large difference in totals for pension payments and contributions in 2015 is due to an error in the version of the ADAM database. This will be corrected when the database is updated. Also note, that the perfect fit for bequests and the media tax is artificial. After the creation of the profiles, they are scaled so that the sums match the totals from the national accounts. For most variables, this is done in the following way: Let  $X_{a,t}$  be the variable of interest, that is to be scaled, and let  $X_{aTot,t}$  be the corresponding total from the national accounts. The scaled profile,  $X_{a,t}^{Scaled}$  is then simply given by

$$X_{a,t}^{Scaled} = X_{a,t} \frac{\sum_a X_{a,t} nPop_{a,t}}{X_{aTot,t}}$$



Table 1: Ratios of national account totals compared to sum of profiles

Variables	2015	2016	2017	Variables	2015	2016	2017
vtHhAM	0.997	0.995	1.014	vPensIndb	1.349	1.000	1.020
vtKommune	1.013	0.983	0.986	vPensUdb	1.806	1.003	1.027
vtBund	1.000	1.000	1.007	vBolig	0.977	0.992	1.008
vtTop	1.018	1.011	1.044	vHhUdlAktier	23.003	23.395	21.582
vtKirke	0.984	0.985	0.988	vHhIndlAktier	2.954	2.827	2.477
vtEjd	1.001	1.000	0.988	vHhObl	1.212	1.659	1.617
vtAktie	1.079	1.494	1.285	vHhBank	1.308	1.256	1.318
vtHhVaegt	0.824	0.816	0.815	vHhRealKred	1.011	1.020	1.035
vtMedieSats	1.000	1.000	1.000	vHhBankGaeld	1.214	1.186	1.278
vtVirksomhed	1.104	1.015	1.128	vHHx	3.570	3.346	2.773
vtPersRest	1.125	1.534	1.332	vArv	1.000	1.000	1.000
vtHhx	1.021	1.016	1.014	vHhxAfk	2.258	0.495	1.306
vPrimInd	1.043	1.006	1.014	vBidrag	0.944	0.942	0.941
vW	1.016	1.008	1.005	vC	0.989	0.953	1.096
vHhOvf	1.067	1.063	1.064				

The ratio are calculated as the relevant total from the national accounts divided by the sum of the profile, i.e.  $\frac{X_{aTot,t}}{\sum_a X_{a,t}nPop_{a,t}}$

The consumption profile created in Section 3 is also scaled in this way. This scaling simply amounts to multiplying the entire profile by a constant factor. However, some variables are handled differently. Profiles that are aggregates of other profiles, such as  $vtHhx_{a,t}$ , are recalculated as the aggregates of the scaled profiles. The aggregate profiles will, therefore, change, since their components are scaled by different factors. Returns are recalculated using the scaled assets profiles and the return rates described in Section 2.6. The rates are constructed so that the new returns will match the flows from the ADAM database. Bequests are also recalculated using the scaled wealth profiles with the method described in Section 2.8.

While the scaling makes the profiles consistent with national accounts, it breaks the temporal consistency, i.e., the budget constraint for each age group no longer holds. This happens because all profiles are scaled by different factors. The budget constraint from MAKRO is used to calculate the resulting temporal error. To do this, the accounting variable  $vHhNFErest_t$ , which is described in Section 3 needs to be distributed across age groups. This is done based on the wage and transfer profiles,

$$vHhNFErest_{a,t} = vHhNFErest_{aTot,t} \frac{vW_{a,t} + vHhOvf_{a,t}}{vW_{aTot,t} + vHhOvf_{aTot,t}}$$

Furthermore, the lagged versions of stock variables can no longer be used, as they are not consistent with the national accounts. Instead the correction factors from MAKRO,  $fMigration_{a,t}$  are used. As stated in Section 3 multiplying a wealth variable with this factor amounts to assuming that the average person who dies is as wealthy as average person who survives and that persons who migrate have no wealth. Using these definitions the temporal error can then be calculated using the following budget constraint

$$\begin{aligned} vFejl_{a,t} = & (vHHx_{a-1,t-1} + vHhxAfk_{a,t}) fMigration_{a,t} - vHHx_{a,t} \\ & + vW_{a,t} + vOvf_{a,t} - vtHhx_{a,t} \\ & + vPensUdb_{a,t} - vPensindb_{a,t} \\ & - vBoliqUdgift_{a,t} + vARV_{a,t} \\ & + vHhNFErest_{a,t} - vC_{a,t} \end{aligned}$$

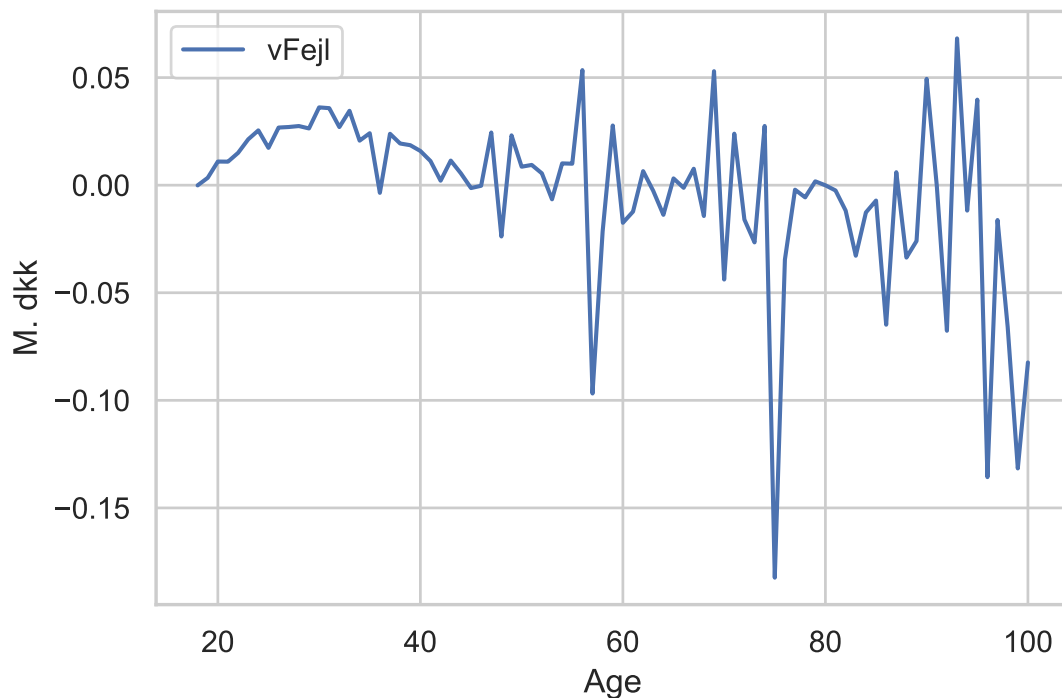
The resulting temporal error profile is shown in Figure 4.1. Note that this since all profiles have been scaled to the national accounts, the sum of errors will be zero,

$$\sum_a vFejl_{a,t} nPop_{a,t} = 0$$

## 4.2 Allocation of temporal error

For temporal consistency to be restored, the error calculated must be inserted into the budget constraint. This can be done in a number of ways. The chosen method

Figure 4.1: Temporal error due to scaling



*The profile shown is based on data from DST. Profile is for 2016.*

is to assume that errors are unobserved intergenerational transfers. Since the sum of the errors is zero, this does not break the aggregate budget constraint. The budget constraint would then simply be

$$\begin{aligned}
 vHHx_{a,t} &= (vHHx_{a-1,t-1} + vHhxAfk_{a,t}) fMigration_{a,t} \\
 &+ vW_{a,t} + vOvf_{a,t} - vtHh x_{a,t} \\
 &+ vPensUdb_{a,t} - vPensindb_{a,t} \\
 &- vBoligUdgift_{a,t} + vARV_{a,t} \\
 &+ vHhNFErest_{a,t} - vC_{a,t} - vFejl_{a,t}
 \end{aligned}$$

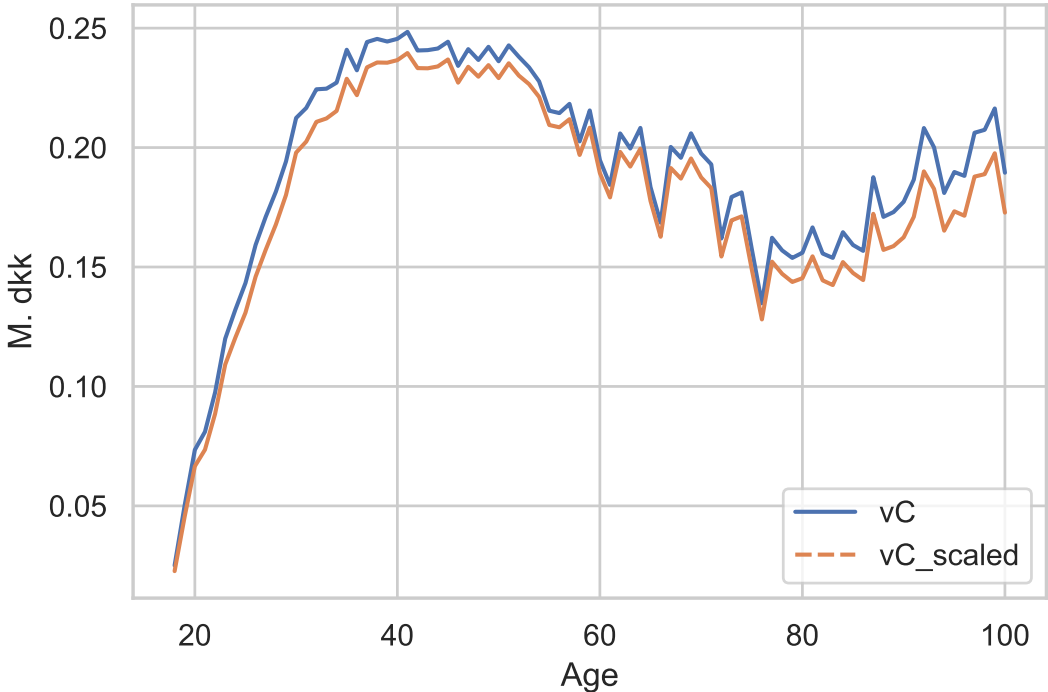
One might ask why the temporal error is not seen as measurement error and attributed to one of the existing profiles. The disadvantages of this approach are discussed in Section A.1.

The allocation of the temporal error to different profiles might seem like pointless refactoring exercise. However, it is important to note that the profiles are used to calibrate a range of parameters in MAKRO. Parameters determining consumption will be affected by the relative size of consumption compared to wealth and income etc.

## 5 Final profiles

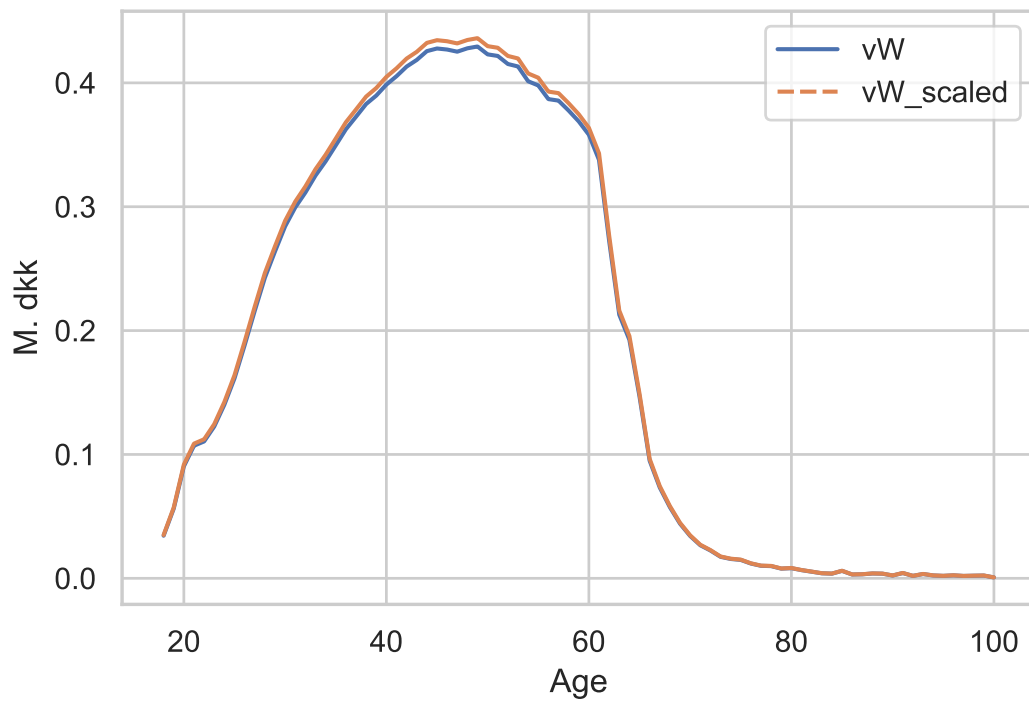
In this section, some final scaled profiles are shown together with non-scaled versions. These include consumption, wages, wealth, and returns.

Figure 5.1: Scaled and non scaled consumption profiles



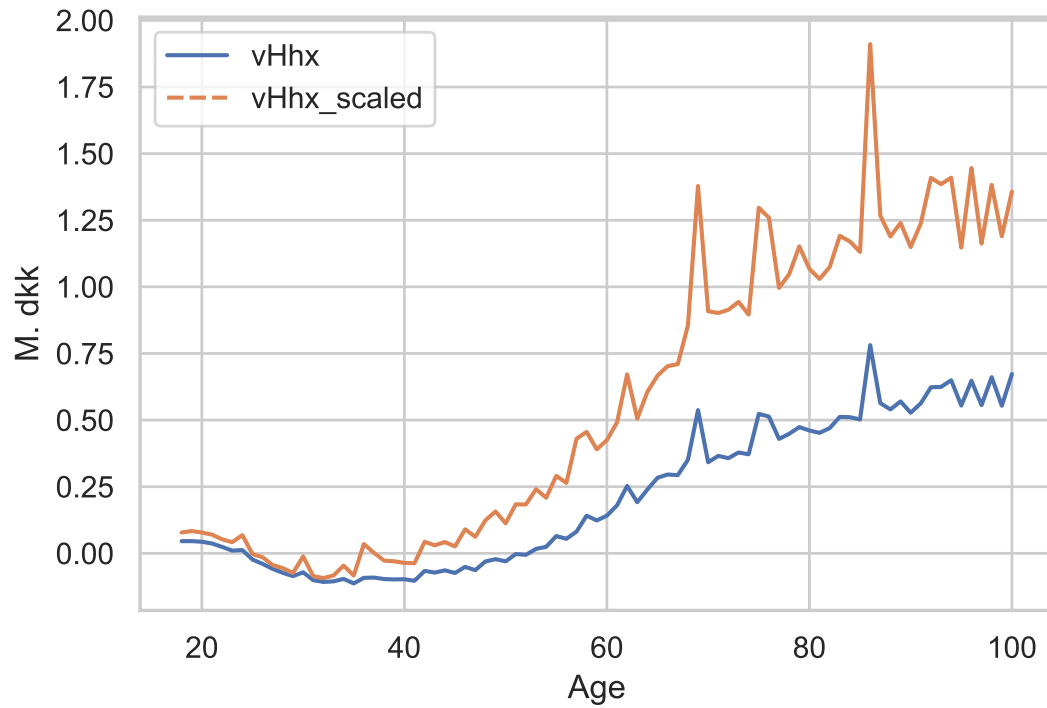
*The profiles shown are based on data from DST. All profiles are for 2016.*

Figure 5.2: Scaled and non scaled wage profiles



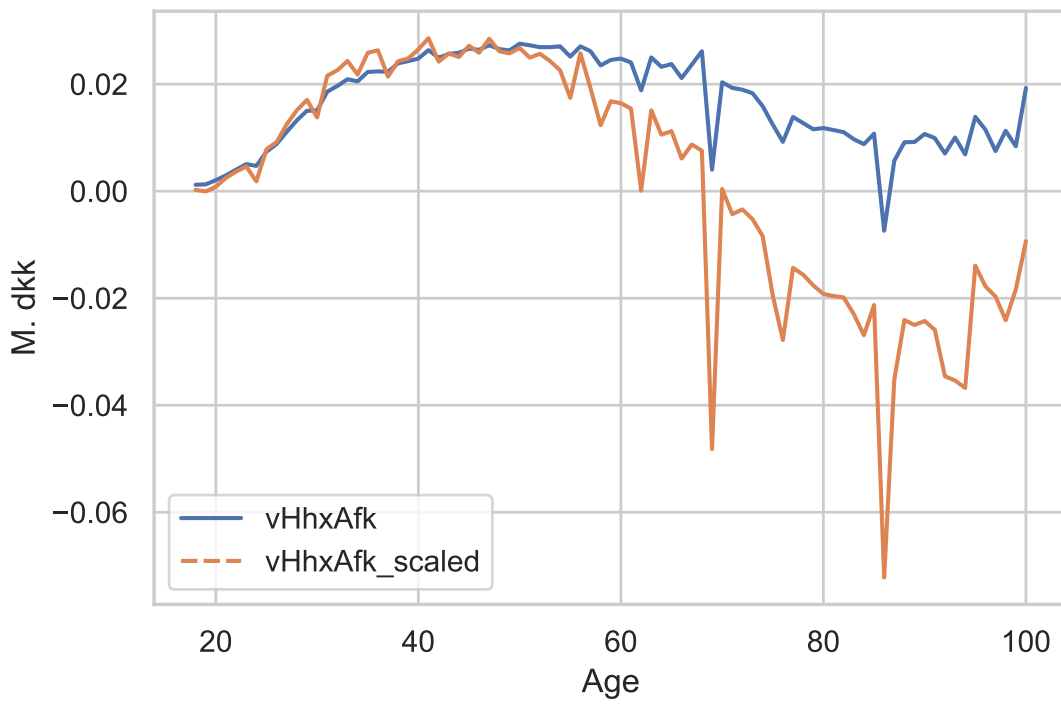
*The profiles shown are based on data from DST. All profiles are for 2016.*

Figure 5.3: Scaled and non scaled financial wealth profiles



*The profiles shown are based on data from DST. All profiles are for 2016.*

Figure 5.4: Scaled and non scaled financial return profiles



*The profiles shown are based on data from DST. All profiles are for 2016.*

## References

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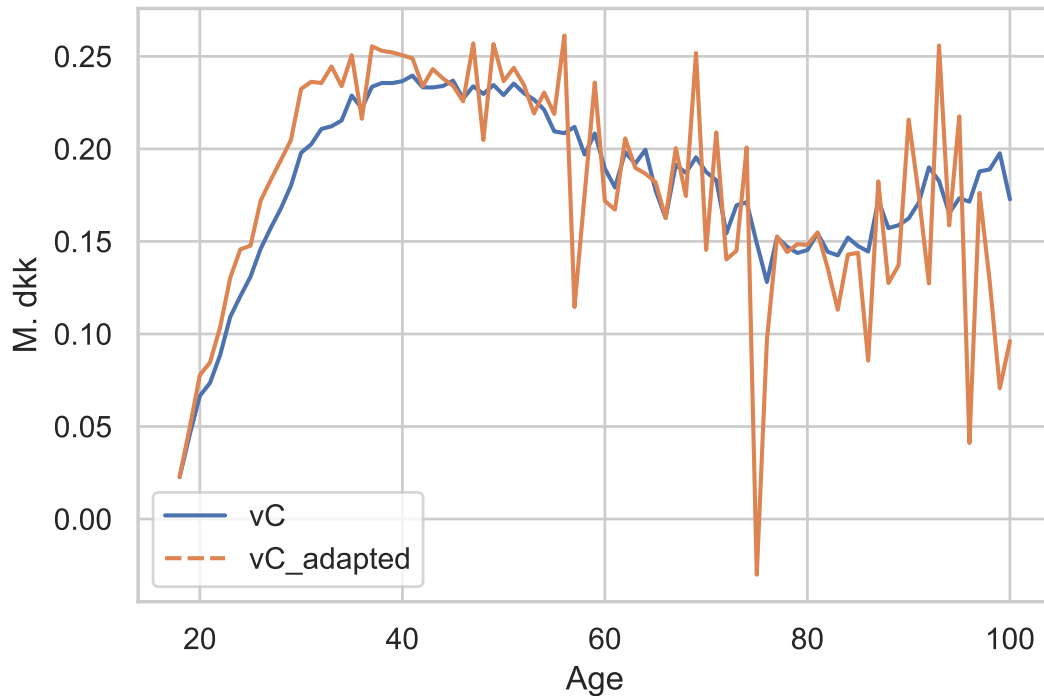


# A Appendix

## A.1 Comparison of methods for allocation of temporal error

In this section, the possibility of allocating the temporal error to existing profiles is discussed. One possibility is to add the error to the consumption profile. This is equivalent to imputing consumption after scaling to the national accounts. Figure A.1 shows the resulting consumption profile. It is apparent that this an unusable profile. Consumption is negative for some age groups and unreasonably fluctuating. Another

Figure A.1: Consumption profile with added temporal error



*The profile shown is based on data from DST. vC\_adapted includes temporal error.*

*All profiles are for 2016.*

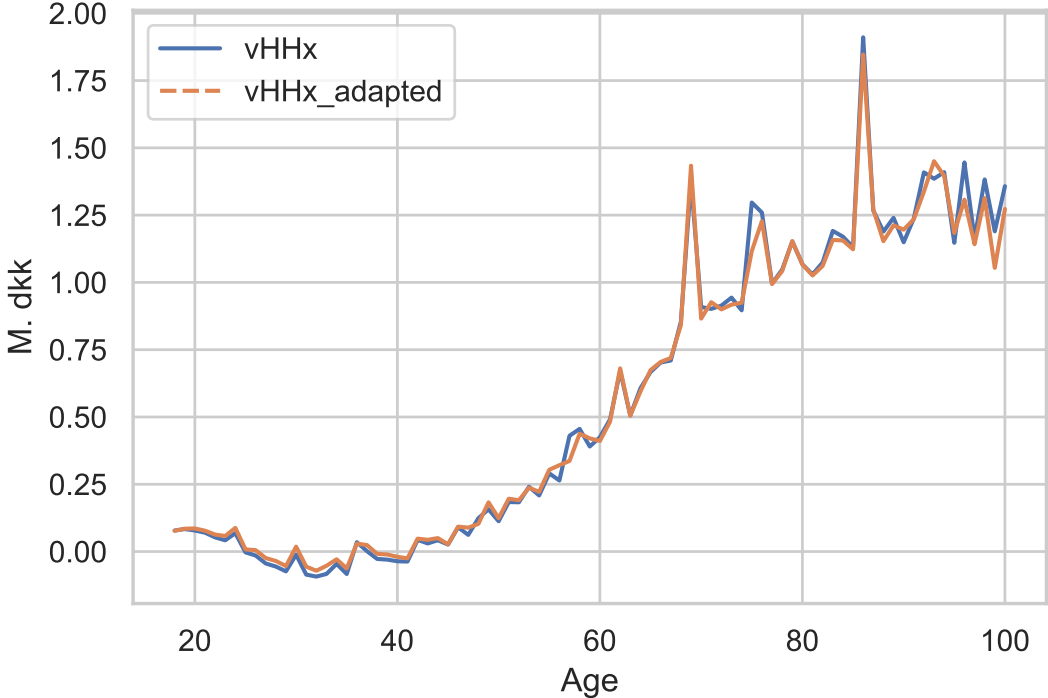
method would be to attribute the temporal error to measurement error in stocks. As described in Section 4.1 and seen in Table 1, this is one of the profiles with the largest difference between administrative data and the national accounts. The temporal error

is also fairly small compared to the financial assets profile. As seen in Figure A.2, the wealth profile is not changed markedly by correction. However, this method has a different drawback. When the wealth profile in period  $t$  is changed to correct for the temporal error in budget constraint in period  $t$ , the temporal error in budget constraint for period  $t + 1$  is also changed, since the wealth at time  $t$  is a component in both budget constraints. The temporal error in period  $t + 1$ , therefore, changes to

$$v\bar{F}ejl_{a+1,t+1} = vFejl_{a,t}fMigration_{a+1,t+1} + vFejl_{a+1,t+1}$$

This means that the assets profiles in all periods will depend on the chosen start period. This is an undesirable property, as it might often be the case that updates to databases result in changes in the periods used.

Figure A.2: Financial wealth profile with added temporal error

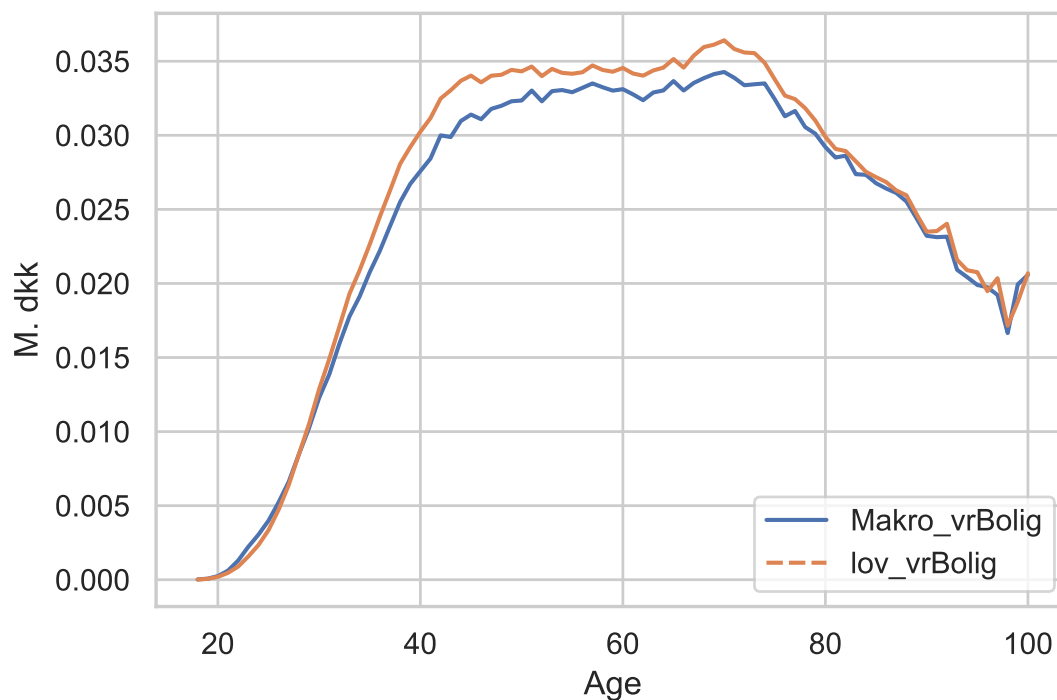


*The profiles shown are based on data from DST and own calculations. vHHx\_adapted includes temporal error. All profiles are for 2016.*

## A.2 Comparison with returns from Lovmodel

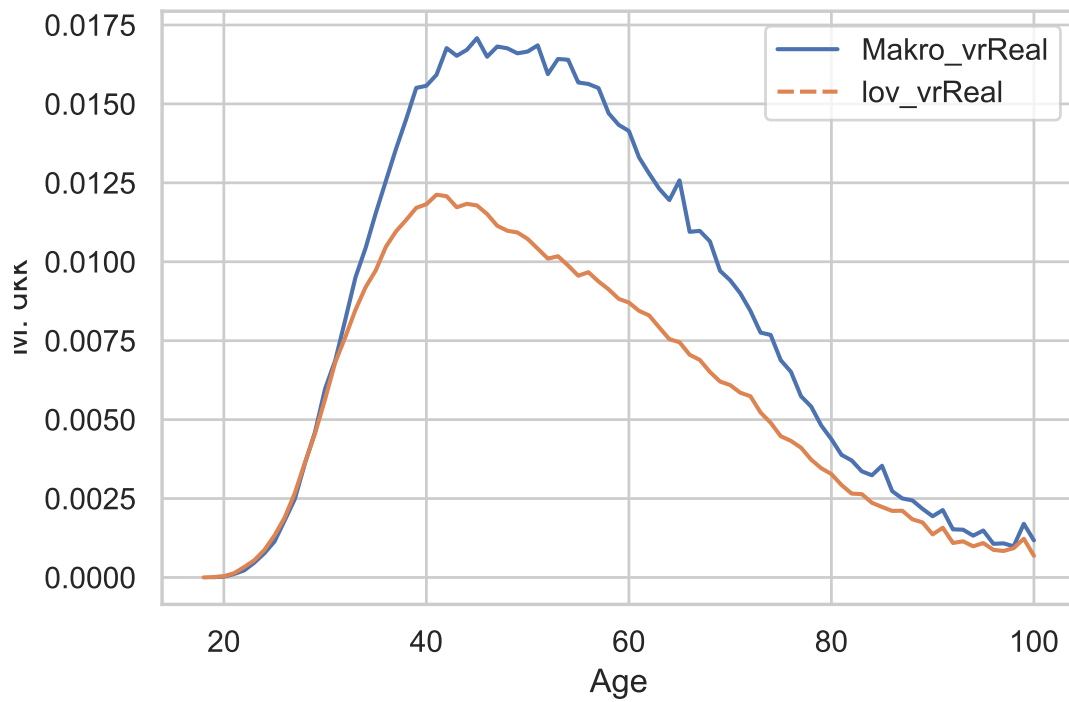
In this section the return profiles created in section 2.6 are compared to the profiles directly available in Lovmodel. Figure A.3 shows that returns to real estate are almost identical. This indicates that the returns to real estate in Lovmodel were created in the same way and applied to a slightly different real estate stock profile. Figure A.4 shows the difference in the cost of mortgage debt. While the level is somewhat different, the shapes are very similar. After scaling, the cost profiles would, therefore, be very similar. Finally, Figure A.5 shows the profiles for returns to net financial assets, excluding mortgages and pensions. Here it is important to note that the definitions differ, so the two profiles are measuring somewhat different things.

Figure A.3: MAKRO and Lovmodel returns on real estate



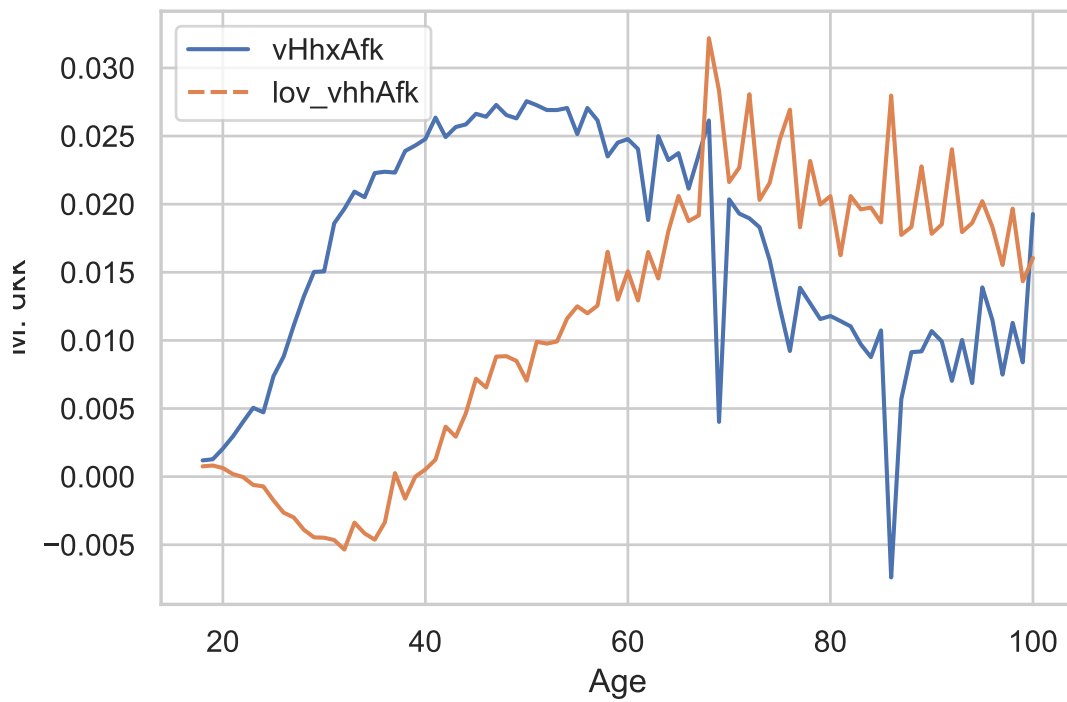
*The profiles shown are based on data from DST. All profiles are for 2016.*

Figure A.4: MAKRO and Lovmodel returns on mortgages



*The profiles shown are based on data from DST. All profiles are for 2016.*

Figure A.5: MAKRO and Lovmodel returns on financial assets



*The profiles shown are based on data from DST. All profiles are for 2016.*