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MAKRO

Marginal propensity to consume

The MPC of temporary and permanent income shocks by age

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1 Introduction

This note describes how the beta bersion of MAKRO is calibrated to provide empirically substantiated levels of private consumption by age. In addition, it is examined how households' marginal propensity to consume (MPC) varies by age. An important goal is to get a MPC that corresponds to Danish empirical results, both at the aggregate level, but also over the life cycle.

In MAKRO, private consumption is not determined by one representative agent, but instead by a series of cohorts via an overlapping generations (OLG) structure. The model thus takes into account the very large differences in wealth and consumption over the life cycle that are observed empirically (see, e.g. Figure 2). Each generation consists partly of forward-looking agents and partly of hand-to-mouth households (HtM).

In the work with MAKRO, we have included the financial part of the national accounts, so that there is full agreement between the overall model and the national accounts at a relatively detailed level. It has been assessed that empirically sound age profiles of household income, wealth, and private consumption are a central element in the empirical properties of MAKRO. Thus, the cohort structure of the model is fully exploited, e.g. when used to make a baseline forecast. In addition to ensuring that age profiles match the *levels* in the data it is also necessary that households in MAKRO have empirically reasonable marginal propensities to consume out of an income shock.

In conclusion:

- The age profiles in MAKRO are calibrated so that the levels fit the data. As a first principle, this is done by calibrating age dependent discount factors so that the correct consumption profiles are obtained.
- Due to the youngest and oldest age groups, it is not possible to fit the age profiles for consumption and wealth to the data via the discount rate alone if this is restricted to be positive. We solve this by including utility of wealth and bequests for the respective age groups.
- To compare the MPC by age in MAKRO to the microeconometric literature, we construct a partial equilibrium version of MAKRO. The status of this work is that MAKRO - for the most central cohorts - is able to replicate the declining profile seen in Danish data.

- The aggregate MPC in MAKRO depends greatly on the type and persistence of a shock. In the partial equilibrium model, first-year aggregate MPC ranges from **0.44** for a temporary income shock[1] **to 0.58** for a permanent income shock[2].

2 Model

The consumer in MAKRO is modeled with a so-called OLG structure, i.e. an actual modeling of each generation. It is assumed that a proportion of households are HtM, so that they spend their entire current income in each period. The rest are assumed to be rational forward-looking agents. A mix of forward-looking and constrained households is essential in order to fit the empirical MPC at the aggregate level.

This section describes the forward-looking household. The model is simplified to emphasize the most important elements, e.g. time is suppressed. The discounted expected utility U_a for an a-year-old is given by:

$$U_a = u_a + \sum_{x=a+1}^{100} \left[s_x \left(u_x + W_{x-1} \right) + \left(1 - s_x \right) W_{x-1}^{\text{beq}} \right] V_x S_{x-1}, \tag{1}$$

where u_x is instantaneous utility from consumption experienced at age x. Households have the probability s_x to survive age x. As can be seen from (1), the household has three sources of utility. If the household survives the age x (this happens as mentioned with the probability s_x) utility is obtained partly from the usual channel u_x (instantaneous utility from consumption) and from utility from keeping wealth where W_{x-1} indicates the relevant concept of wealth in utility.[3]

Utility of wealth is typically explained by the status associated with being wealthy. Another explanation that is more relevant in our case is that wealth guards one against uncertainty. Utility of wealth can therefore be seen as a precautionary motive and leads to behavior in households that is very similar to credit rationing. The third source of utility is bequests. If the household dies (which happens with the probability $1 - s_x$) the utility W_{x-1}^{beq} is obtained. The reason for including all these sources of utility is the desire to fit data. The bequest motive is included to describe the behavior of older households. Utility of wealth is included to have a realistic behavior for households early and in the middle of life.

The instantaneous utility of consumption is given by a so-called CRRA utility function:

$$u_x = \frac{\tilde{u}_x^{1-\eta}}{1-\eta}, \tag{2}$$

[1] The temporary shock has a persistence of 1.5 years. The result is robust to giving the same weight to all households (age 18 or above) or having the weights or the shock itself proportional to income.

[2] In the permanent shock, we apply a proportional shock to the income of the household in each period.

[3] The wealth in utility are net assets incl. housing, mortgages and limited pension instruments (capital and retirement pensions) for forward-looking households. Retirement and capital pensions are included, as these are arrangements that people themselves have paid in addition to their labor market pensions, and to some extend can choose when to pay out following retirement. Therefore, in this context, they are seen as close substitutes to free savings.

where η is the parameter for relative risk aversion. $1/\eta$ can be interpreted as the intertemporal elasticity of substitution. This parameter therefore determines how much households smooth their consumption over time. The utility $\tilde{u}_x$ is given by

$$\tilde{u}_x = \left[(1-\vartheta_x)^{\frac{1}{E}} \left(C_x - \chi^C C_{x-1} \right)^{\frac{E-1}{E}} + \vartheta_x^{\frac{1}{E}} \left(D_x - \chi^D D_{x-1} \right)^{\frac{E-1}{E}} \right]^{\frac{E}{E-1}},$$

where C_x is consumption of goods and services and D_x is housing stock. The parameters χ^C and χ^D determine the degree of habit formation in consumption.

The utility of bequest is given by:

$$W_{x-1}^{\text{beq}} = \xi^{\text{beq}} \frac{\left(X_{x-1}^{\text{beq}} - \kappa^{\text{beq}} \right)^{1\text{-}\eta}}{1-\eta}, \tag{3}$$

where

$$X_{x-1}^{\text{beq}} \equiv \left(1-\tau^{\text{beq}}\right) \left[(1+r_x) B_{x-1}^{\text{beq}} + p^D (1-\mu_x) D_{x-1} \right].$$

Here B_{x-1}^{beq} is the relevant concept of non-housing wealth in relation to bequests[4], p^D is the house price and μ_x is the share of mortgage in the house.

The utility of wealth is given by:

$$W_{x-1} = \xi \frac{(X_{x-1} - \kappa)^{1\text{-}\eta}}{1-\eta}, \tag{4}$$

where

$$X_{x-1} \equiv (1+r_x) B_{x-1} + p^D (1-\mu_x) D_{x-1},$$

and X_{x-1} is the total realizable net wealth, with B_{x-1} being the realizable non-housing wealth.

The discount factor V_x is given by:

$$V_x \equiv \prod_{v=a+1}^{x} \beta_v,$$

where β_v is the household's subjective discount rate.

S_{x-1} measures the probability of surviving from age a to the beginning of age x:

$$S_{x-1} \equiv \prod_{v=a+1}^{x-1} s_v.$$

3 Age profiles: Data and model

As no administrative data exists for private consumption at the individual level, the age profile of consumption in MAKRO is imputed based on age-distributed profiles

[4]The bequest wealth is total non-housing wealth including only the part of the pension wealth that is paid out in case of death.

for after-tax income, wealth, and interests (Browning & Leth-Petersen 2003). Figure 1 shows the age profile of non-housing consumption imputed from 2017 administrative data as well as the distribution of income and home ownership. Consumption closely tracks income over the life-cycle, underlining the need for HtM households and/or a soft credit constraint in order to fit the data. However, consumption is also significantly smoother than income as is the case for the forward-looking households in MAKRO.

Figure 1: Age distribution of income, consumption and housing in 2017.

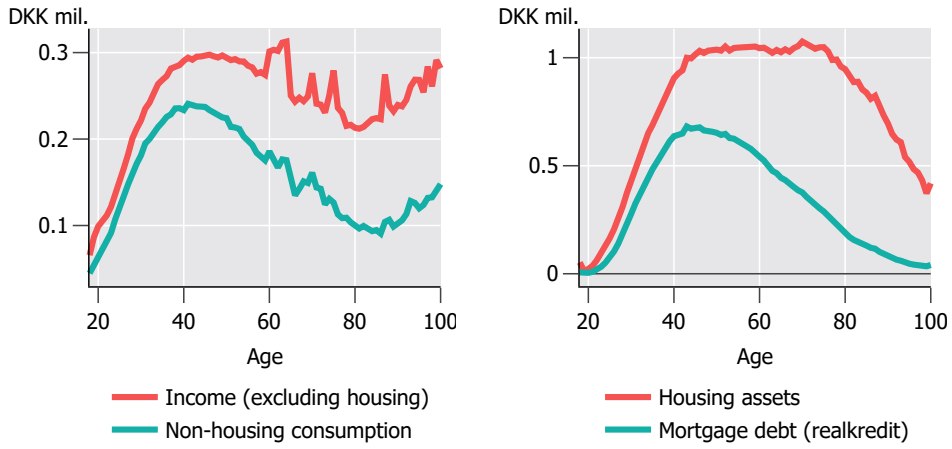
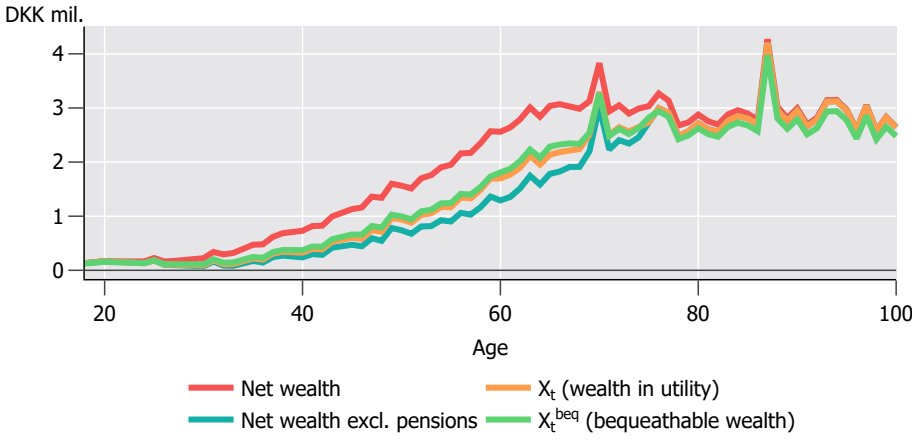


Figure 2 shows the age profile of net wealth from 2017 administrative data along with the wealth and bequest objects in the utility function defined in the previous section.

Figure 2: Age distribution of wealth in 2017.



As a first principle, the age-distributed discount rate β_x is calibrated to match the consumption profiles in the data. However, this approach is problematic for certain age groups when the calibration is based on the simplest version of the utility function in MAKRO:

First, without altruistic preferences, any positive discount rate results in the older cohorts (from about 80 years) saving too much (consuming too little of the wealth) compared to the data - this result is well known from the literature. As a result, calibrating the model to match the consumption of old cohorts - in the absence of a bequest motive - results in negative discount factors, which are neither realistic or meaningful. This is solved by including an age-dependent *warm glow* motive via two bequest parameters in the utility function, ξ_x^{beq} and η_x^{beq}, while keeping the discount factor constant when the cohorts reach a certain age.

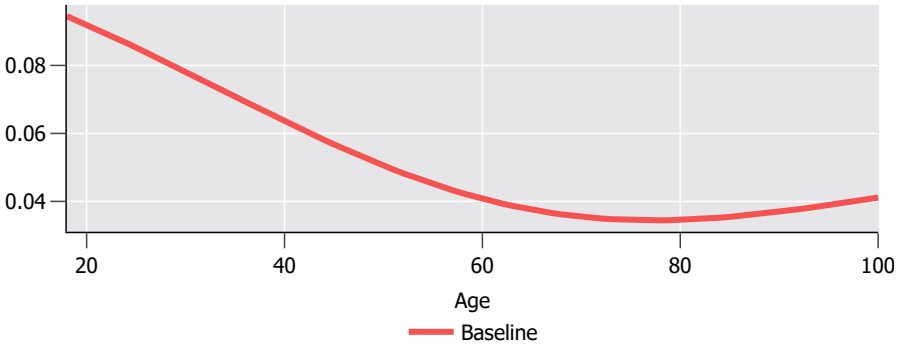
Secondly, there seems to be some degree of credit rationing for households in the beginning and middle of working life.[5] Indications of such a "soft" credit rationing are reflected in a consumption profile that is steadily rising for these age groups as the income of the cohorts also increases gradually. Credit restrictions, including those that arise as a result of uncertainty, will also tend to reduce the calibrated discount rate. The problem of low discount rates for young households is solved by introducing an age-dependent parameter for utility of wealth, ξ_x, which increases the calibrated discount rate all other things being equal. The discount factor is kept constant up to a certain age (prior to smoothing the parameter). Note that the level of the entire profile could be calibrated to be positive in the middle of life (by changing the weight on bequests), but only with wealth in the utility function do we moderate the sharp increase in discount rates from 20 to 40 years of age. The parameter for utility of wealth may reflect several factors: For example, precautionary savings due to unmodeled uncertainty will result in lower consumption and thus lower discount factors than those one would get if uncertainty explicitly influenced consumers' decisions.

Third, in the absence of wealth in the utility function, there are negative discount rates for the youngest adults, i.e. age groups between 18 and 25 years or age.[6] Here, on the other hand, there is probably to some extent a data problem: the imputed consumption is unrealistically low for people under 25 years of age. This is probably due to unregistered transfers from parents (support for current consumption and housing costs). The problem is also solved by including wealth in the utility function as described above.

[5] It should be noted that children have been taken into account in relation to the utility function of households, so this is not the reason for the low discount rates. The habit adjusted consumption is calculated as $C_a/(1+0.5\times \text{children}_x) - \chi^C C_{a-1}/(1+0.5\times \text{children}_{a-1})$ where children_a is the number of children of an average a year old individual.

[6] Consumption of individuals younger than 18 years are placed with their parents.

Figure 3: Calibrated discount rates after smoothing.



Note: The figure displays results from the ultimo june 2021 version of MAKRO.

In summary, MAKRO replicates the imputed age profile of private consumption, for a large part of the cohorts, primarily by means of calibrated discount rates, but for the oldest and the youngest it is necessary to include utility of bequests and wealth to get reasonable (positive) discount rates. Note that the age profiles based on administrative data are scaled such that, for example, the sum of the individuals' private consumption corresponds with the national accounts. This is necessary as these are different data sources that are not completely matched, cf. Hoeck and Bonde (2021). Finally, the discount rate and other age varying parameters are smoothed before forecasting to prevent overfitting the data.

4 Marginal propensity to consume

As described in the section above, the model is calibrated to replicate empirical age profiles in a base year. This ensures that the *level* of private consumption is reasonable across cohorts. In addition, it is crucial that household behavior in marginal experiments is also reasonable. Here, one is typically interested in the MPC out of changes in households' income. However, the measure of MPC depends critically on how housing consumption and capital gains are treated. In general equilibrium, an increase in the income of all households can lead to increases in housing prices that substantially affect the size of the income change when capital gains are included in the measure of income. National accounts use a concept of housing consumption calculated as the rental value of the housing stock, which means that HtM households have MPCs below 1 as their immediate cost of housing investments are not counted as consumption. The national accounting thereby understates the changes consumption *expenditure* compared to a definition of imputed consumption expenditure that includes housing investments. In the microeconometric literature, these issues can be mostly avoided by excluding households with real-estate transactions within a certain period from the sample.

At the most aggregate level, MPC describes the model's overall consumption response to shocks. Aggregate MPC is not directly calibrated, but is implicitly deter-

mined through matching to aggregate empirical impulse response functions (IRFs) from estimated SVAR models. Due to the forward-looking agents in the model, the MPC varies significantly depending on the whether the income shock is temporary or permanent. In the full general equilibrium model, the MPC also varies depending on the nature of the shock. However, the resulting MPCs of income shocks presented in the following are roughly equivalent to the short-term MPC found in other Danish models, such as ADAM and SMEC, where the first-year response of consumption to changes in income is around 0.4-0.5. In addition, there is a relatively extensive empirical literature that has examined the average propensity to consume using Danish microdata. Here, the average MPC is also typically estimated to be around 0.5.

Due to MAKRO's OLG structure, we can also study the households' MPC by age. In the literature, only few studies have examined the age profile of MPC on Danish data. In summary, there is agreement that the profile is declining over life: Crawley & Kuchler (2018) find a MPC of approx. 0.7 for 20-30-year-olds, which is declining to around 0.6 at the end of working life, after which it falls relatively sharply. Kreiner et al (2019) include age as a control variable in their analysis and find that MPC decreases by 2 percentage points when household age increases by 10 years. Hvid & Kuchler (2017) report an age profile on the marginal propensity to consume out of changes in housing wealth. This too has a generally declining profile for different periods - at least when the very youngest homeowners are disregarded. Thus, although there is agreement that the age profile of MPC is declining over life, there is less agreement on the order of magnitude. For several of the studies, the age profiles are also a small part of a larger analysis, just as the income and consumption concepts used may vary and differ from those we use in MAKRO. A possible future project could therefore be that the MAKRO group itself estimated the MPC distribution over life, based on Danish microdata and which can subsequently be held up against the model.

To most closely match the measures of MPC used in the microeconometric literature we construct a partial equilibrium version of MAKRO, which consists of Euler equations, income definitions, and budget constraints.[7] In this model we can analyze what happens when we shock a single or few households without affecting aggregate market conditions. To abstract from the issue of housing consumption, we exogenize the housing investments of the household in the first year of the shock, in line with microeconometric studies that exclude households with real-estate transactions from their sample.

Figure 4 shows the MPC by age in the first year of an income shock in a partial equilibrium version of MAKRO, for a temporary and permanent income shock respec-

[7]The partial model of household consumption and savings behavior consists of the subset of the equations in MAKRO that directly relates to these decisions. Equations that relate to other parts of MAKRO (eg the production sector, the public sector and foreign trade) and which more indirectly (via general equilibrium effects) affect these decisions are not included. The endogenous variables determined in these parts of MAKRO are thus exogenized in the partial model. Central to the partial model is the consumption and saving behavior of households, and for both types of households, consumption (excluding housing), the amount of housing and wealth are endogenous in the partial model. Household reference consumption is also endogenised to maintain inertia in the consumption response. For households in particular, income is exogenised in terms of wages, employment, government transfers and capital transfers, and further exogenised variables with a direct impact on household choices include housing and consumer prices. The same partial model is used to assess marginal propensity and crowding out of pension savings.

tively. In the temporary shock, income increases for two periods, with the effect being halved in the second period. This level of persistence is chosen to roughly match the persistence in the microeconomics studies that we compare to. It can be seen that for a temporary shock, the profile is declining in age: From 0.5 for the 19-year-olds to 0.41 for 80-year-olds.[8] In a permanent income shock we increase households' incomes proportionally in all periods, so that all households have the same relative increase in remaining lifetime income. Here, MPC increases with age up to 0.65 at the age of 40 and then declines afterwards.

Figure 4 also shows that the persistence of the shock is important for the order of magnitude of the MPC: In the case of permanent shocks, the consumption response is much greater for all age groups. This illustrates an important property of MAKRO: Some consumers optimize under forward-looking expectations, which means that permanent shocks generally have greater effects than temporary shocks, even in the first year.

Figure 4: MPC in the first year by age. Temporary and permanent shocks.

MPC in MAKRO generally declines with age as suggested by the literature. In the partial model, aggregate first-year MPC ranges from 0.44 for a temporary income shock to 0.58 for a permanent shock. For temporary shocks, we generally find MPCs that are close to or slightly smaller than the microeconometric studies that we compare the model against.

Figure 5 shows the first-year MPCs of HtM and forward-looking consumers for the temporary and permanent shock to the partial model. With exogenous housing investments in the first period, all HtM households have an MPC of exactly 1. As such, the age profiles of the average household discussed above only reflect the age-dependent behavior of the forward-looking households. It is clearly straight forward to

[8]The sharp spike in MPC for 18-year olds is a result of them having a different specification of habit consumption. While 19-year olds have previous 18-year olds as their reference group, 18-year olds have themselves as their reference. This implies that 18-year olds and 19-year olds have the same reference group albeit 19-year olds have greater income and thus a smaller share of their consumption is habit consumption. This result in 18-year olds having a significantly higher MPC than all other age-groups.

increase the overall MPC, by simply increasing the share of HtM consumers.

Figure 5: First-year MPC by age and household type.

In conclusion, in the beta version of the model it is possible for MAKRO to generate reasonable age-variant MPCs (i.e. at the micro level) and at the same time give reasonable MPCs in face of aggregate shocks. These good marginal properties of the model is obtained while fitting the age distribution of the *level* of consumption by age imputed from register data.

5 References

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