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Effects of Preferential Tax Treatment on German Homeownership

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Abstract

The paper analyzes the effects of mortgage interest deductibility and untaxed imputed rental income on the German homeownership. I use a general equilibrium life-cycle framework, where a minimum down-payment constraint on purchases of housing capital is the critical element of the model framework. I find that both tax policies would increase Germany's low homeownership rate. However, these tax policies would entail substantial welfare losses for individuals of all income quintiles in the long run. Finally, wealth effects are relatively small and the welfare analysis shows that individuals would prefer to live in an economy without preferential tax treatment of housing. (JEL: E62; H3)

Keywords: German homeownership rate; Housing taxation; Imputed rents; Mortgage deductibility; Capital accumulation.

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1. Introduction

Governments across the globe strive to increase homeownership rates. High homeownership rates are desirable for various reasons. Homeownership is often considered for old-age provision, especially when publicly funded pension rights are low. On the micro-level, homeownership is often considered favorable compared to renting by means of positive externalities. It may positively affect wealth accumulation, is associated with better education for children and is often found to be positively correlated with engagement in communities and better neighborhood maintenance (Coulson and Li, 2013; Mathä et al., 2017; Andrews and Sánchez, 2011).

This paper is a quantitative exercise to analyze two effects of preferential tax treatment on German homeownership: Taxation of imputed rents and mortgage interest deduction. More specifically, the objective of this paper is twofold: First, to study the effects of two different tax policies in terms of preferential treatment of owner-occupied housing capital for the German economy, with special focus on homeownership rates, I use the general equilibrium life-cycle model by Gervais (2002)[1] and calibrate it to the German economy. Second, the implications drawn from the counterfactual experiments for Germany are compared to those of Gervais (2002) for the U.S. and discussed in light of recent advances in literature. The reason I take taxation of imputed rents and mortgage interest deduction as two main factors is because unlike the U.S., Germany does not currently employ those tax policies to improve homeownership.

A recent work by Kaas et al. (2021) is closely related to my work. It analyzes the impacts of different policy changes on the homeownership rate in Germany in a lifecycle model with uninsurable income risk, endogenous homeownership and social housing. While not considering imputed rental income, Kaas et al. (2021) focus on the reduction of the real-estate transfer tax (RETT), mortgage interest deduction and considers the elimination of the social housing sector. Moreover, while all rental housing is owned by financial institutions in Gervais (2002), in Kaas et al. (2021) homeowners can rent out housing capital, too. Additionally, Kaas et al. (2021) assumes preferences to be risk dependent and varying by age. Bequests are distributed randomly. Nevertheless, for simplicity I use the more basic approach by Gervais (2002) and focus on two tax policies that have potentially high distortionary impact on tenure choice: the deductibility of mortgage interest payments and tax exemption of imputed rental income.

1. Gervais (2002) has been refined, among others, by Chambers et al. (2009), Floetotto et al. (2016) and Sommer and Sullivan (2018)

I study the German economy as there are three salient macroeconomic facts for Germany. First, mean net value of homeowners' main residence makes up 38 percent of total net wealth in 2013 (Mathä et al., 2017).[2] With mean contributions of housing capital to total net wealth in euro area countries of 30 percent (Cyprus) - 74 percent (Solvakia), Germany ranks second lowest (Mathä et al., 2017). Second, with 44 percent Germany's homeownership rate ranks lowest of all euro area countries in 2013 and at the bottom end among developed countries. Using the Eurosystem Household Finance and Consumption Survey 2013, Mathä et al. (2017) reveal variations in homeownership rates between 44 percent (Germany) - 90 percent (Slovakia). Third, since 1995, the German government promoted homeownership either via lump-sum subsidies or not at all: The two subsidies are i) the first time homeowners with children promoting "Baukindergeld", in place since 2018 and ii) the "Eigenheimzulage" (EZ) (1995-2005)[3].

The given facts suggest that the German tax code does not favor owner-occupiers (only implicitly by not taxing imputed rents) and the share of housing capital in total net wealth in Germany is smaller compared to other countries in the Euro zone. Nevertheless, housing with its twofold characteristics as consumption as well as investment good, represents the largest asset of most households' portfolio. The corresponding mortgages on the other hand make up most of households liabilities. Thus, housing market policies may not only have considerably large effects on households' investment and consumption behavior but also on real economic activity and financial markets. A combination of a relatively low percentage of housing capital stock with a low homeownership rate for Germany sheds further light on the feasible effects of different tax policies on the homeownership rate and positive effects that relate to homeowners compared to renters. In contrast to the U.S. and European countries, such as the Netherlands and Belgium, German homeowners cannot deduct their mortgage interest payments. However, housing capital is indirectly treated preferential in Germany as imputed rents[4] are not taxed. Thus, the main difference to the U.S. tax code is that mortgage interest payments are not deductible in Germany.

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2. Schmalwasser and Schidlowski (2006) suggest that housing capital makes up 47 percent of the total capital stock in 2006. For the U.S., (Gervais, 2002) reports a share of housing capital in total capital of 55 percent. According to (Harding et al., 2007), the share for the U.S. is only approximately one third.

3. According to the KfW, the former subsidy gives families 12,000 Euro per child if the household income does not exceed 90,000 before taxes. The latter supported homebuyers with around 20,000 Euros over 8 years. Daminger and Dascher (2020) study the impact of a 12 year subsidy removal of the EZ on city shape and societal changes such as rising rents and female labor force participation.

4. The benefit from the return on investment when owner-occupying a house instead of gaining rental income when renting it out (European Comission, 2012).

Distortions gauged by preferential treatment of owner-occupied housing through the tax code are widely discussed in literature. On the one hand, Poterba and Sinai (2008), Rosen (1979), Rosen (1985) and Albouy and Hanson (2014), among others, use the partial equilibrium user cost approach to study the impact of mortgage interest deductibility and other tax subsidies to homeowners on income tax liabilities and the user cost of owner-occupied housing. This literature finds that undertaxation of owner-occupiers results in a substantial amount of foregone tax revenues, reduces the user cost of housing compared to a neutral tax system and as a consequence leads to overconsumption of housing services. On the other hand, using dynamic general equilibrium setups, one can analyze the effects on optimal household choices at the extensive margin (regarding the housing tenure choice).

Although there are numerous studies for the U.S., only a few studies examine preferential tax treatment of housing in the Euro-Area and in particular for Germany. Applying the user-cost approach, Fatica and Prammer (2018) find preferential treatment of owner-occupied housing in the Euro-Area to significantly reduce the user cost of housing leading to an excess consumption of owner-occupied housing services. Frick et al. (2010) is another work that analyzes the impact of preferential tax treatment of housing capital in Germany with focus on distributional effects. Exploiting a reform on the Real Estate Transfer Tax (RETT) in 2006, several empirical studies focus on price effects of RETT rather than the impact on homeownership rates. For example Petkova and Weichenrieder (2017) use aggregated state level data and Dolls et al. (2021) use an extensive micro-level listings dataset on housing transactions. Both find price reductions after a one percentage point increase in the RETT. Petkova and Weichenrieder (2017) in addition find a negative effect on the amount of transactions of single-family housing.

The framework by Gervais (2002) allows one to study the impacts on individuals' behavior as well as on the composition of the aggregate capital stock, long run welfare and distributional consequences for the German economy. The model explicitly focuses on the relationship between tenure choice and tax code, which one can interpret as the main channel of distorting individual decisions.[5] Similar to Gervais (2002), I conduct two experiments with different tax policies. First, I introduce mortgage interest deductibility in addition to the tax exemption of imputed rental income and second, I allow imputed rents to be taxed at the same rate as labor income.

5. Although more recently authors have endogenized house prices and rents (Chambers et al. (2009); Díaz and Luengo-Prado (2008)), introduced progressive income taxation (Sommer and Sullivan, 2018), and specifically analyzed the transitional dynamics from one tax code to another (Floetotto et al., 2016), Gervais (2002) approach enables through its simplicity to focus on the most important distortion channel - the tenure decision - modeled by a minimum downpayment constraint on purchases of imperfectly divisible housing capital.

This procedure delivers several important implications. When owning is preferred over renting, individuals are induced to faster accumulate wealth in their first periods of life. This is done by individuals to meet the downpayment requirements and minimum housing size constraints as soon as possible in order to purchase a house. In the model, this is the case when imputed rents are taxed at a lower rate than other sources of income. Additionally, if mortgage interest payments are not fully deductible then equity is strictly preferred to debt. Contrary, when they are fully deductible, both equity and debt are equivalent and as a result reinforce the over-accumulation of housing capital in the presence of untaxed imputed rents. These results are taken into account by individuals when taking their tenure decision. From the welfare perspective, over-accumulating wealth in early stages of life induces individuals to experience welfare losses as smooth consumption profiles are preferred, while taxing imputed rental income leads to substantial welfare gains in the long run.

The remainder of this paper consists of five sections. Section 2 describes the specific characteristics of the German housing market and the fiscal policy interventions considered in the paper. Section 3 introduces the key implications of the model by Gervais (2002). Section 4 describes the calibration of the benchmark economy and the behavior of individuals in the baseline economy. Section 5 analyses different tax codes with more or less favorable treatment of owner-occupied housing and Section 6 concludes.

2. Housing Market Policies

Numerous policy interventions aim towards promoting homeownership by creating a gap between the relative cost of owner-occupied housing and renting. This section describes fundamental differences of the German residential market compared to other European countries' residential markets as potential reasons for the low homeownership rate. I then discuss permanent government interventions into the housing market through the tax code: Mortgage interest deduction and the tax exemption of imputed rents of owner-occupied housing.

2.1. Why is the German homeownership rate so low?

Figure 1 displays the well known fact that Germany's homeownership rate is with around 50 percent at the bottom end of international rankings. Homeownership rates are seen as an indicator for the level of wealth and a basis for investment decisions (Voigtländer, 2009).

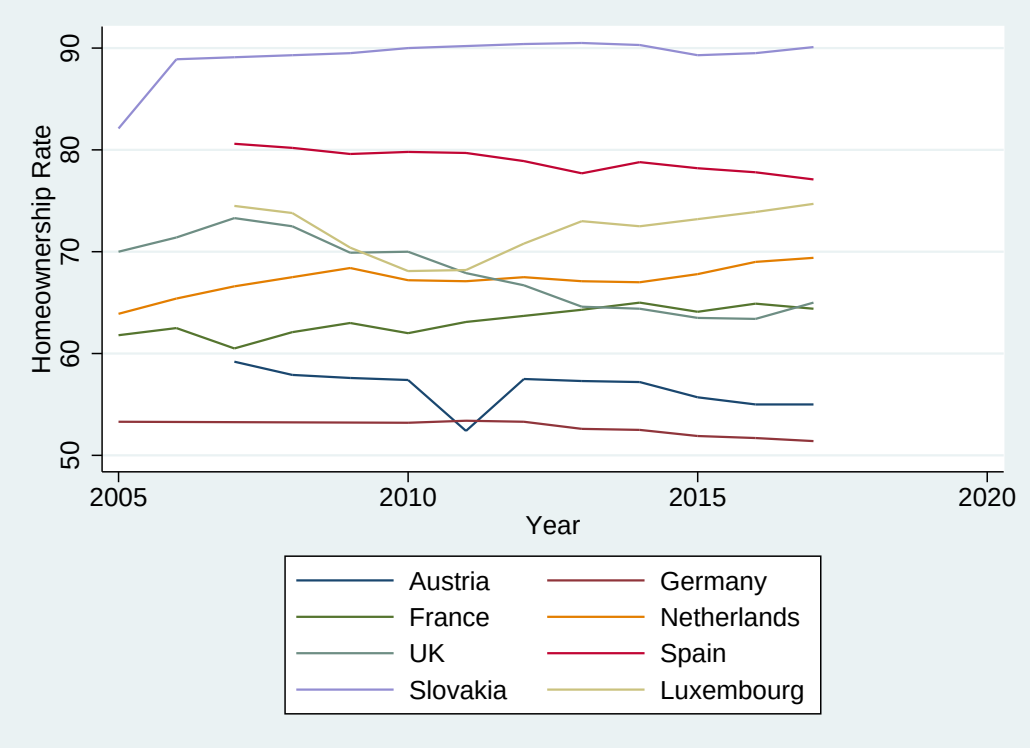

FIGURE 1. Homeownership rates - selected European Countries (Source: Eurostat)

However comparing price-to-income ratios (in Figure 2) as an indicator for the affordability of housing and the GDP per capita (in Table 1) as a measure of wealth of different European countries, Germany ranks at the higher end of the distribution. Thus, taking the homeownership rate as an indicator for wealth appears to be misleading in the German case.

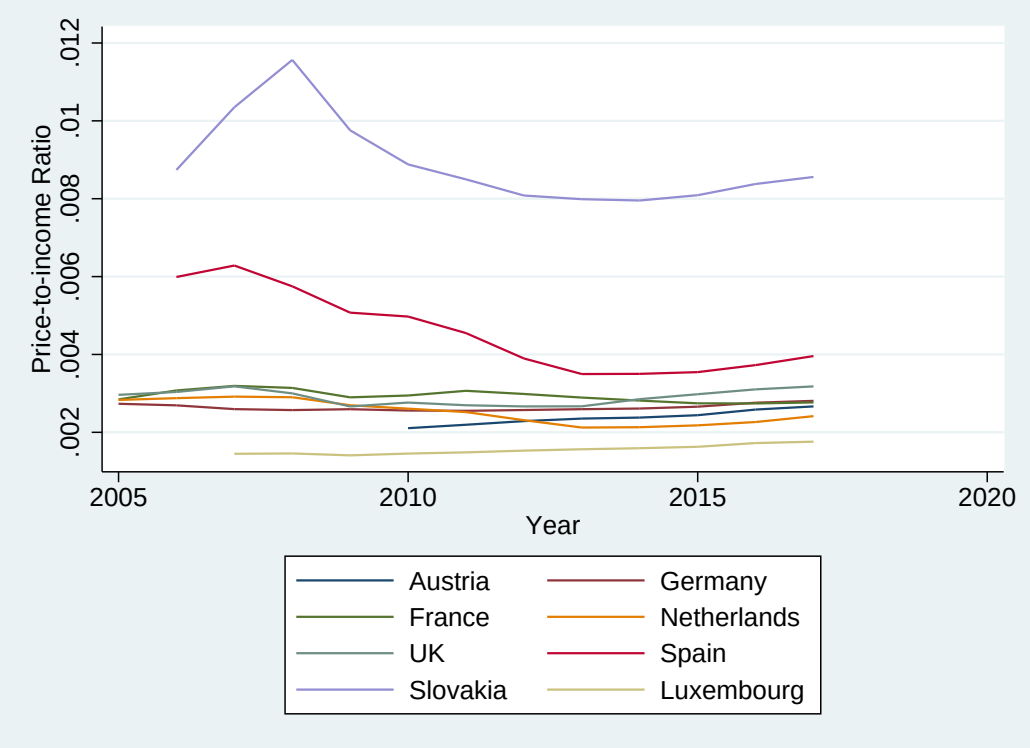

FIGURE 2. Price-to-income ratios - selected European countries (Sources: OECD, Eurostat)

Country	GDP per capita [6]	Average annual wages[7]
Austria	113	50,349
France	97	43,755
Germany	113	47,585
Luxembourg	223	63,062
Netherlands	122	52,877
Slovak Republic	77	24,328
Spain	86	38,507
UK	101	43,732
US	137	60,558

TABLE 1. GDP (Source: OECD)

What are potential institutional and policy factors that hold Germany's homeownership rate low in contrast to those of the U.S. and several countries of the euro zone? First, although imputed rents are not taxed, the tax benefits of homeowners in Germany are less favorable than in neighboring European countries as mortgage interest is not tax deductible for owner-occupiers. Second, the extensive social housing sector with broad eligibility requirements accounts for a large portion of the housing stock. Third, Germany's high real estate transfer tax ranging between $3-5$ percent may provoke high barriers towards homeownership and low turnover rates (Voigtländer, 2009; Kaas et al., 2021).

6. Index using the price levels and PPPs of 2010

7. In 2017 constant prices at 2017 USD PPPs

This paper focuses on the first potential factor for a low German homeownership rate: The absence of mortgage interest deduction (MID). In addition, it explores the effects of taxing imputed rents that are currently exempt from taxation.

2.2. Tax regime and alternatives

The two tax policies in the housing market that are believed to be important for influencing individuals' tenure decisions are: MID and the tax exemption of imputed rents of owner-occupied housing. Housing capital can be seen either as a form of investment good or as a consumption good. Landlords investing into housing capital pay taxes on the income received from rents. In contrast, the implicit income or the rents saved by owner-occupiers are not taxed. As landlords usually pass on their expenditures to their tenants, this creates a bias towards homeownership compared to renting (Voigtländer (2009); Floetotto et al. (2016)). As mentioned previously, the German tax code is less advantageous for homeowners compared to other countries. Important implications of the model to analyze whether a more favorable tax treatment of owner-occupied housing would help to increase German homeownership are outlined in the next section.

3. Model

I build on the life-cycle housing tenure choice model with tax frictions by Gervais (2002). As the model itself is not new it is outlined for expositional purpose in the Appendix. However, before I introduce some key implications of the model by Gervais (2002) framework below, I want to be upfront about three apparent shortcomings of the model. First, it does not model progressive income taxation. Second, it calibrates the same tax rate for income and capital. Third, it normalizes house prices. Although more recently authors have endogenized house prices and rents (Chambers et al. (2009); Díaz and Luengo-Prado (2008)), introduced progressive income taxation (Sommer and Sullivan, 2018), and specifically analyzed the transitional dynamics from one tax code to another (Floetotto et al., 2016), Gervais (2002) approach enables through its simplicity to focus on the most important distortion channel - the tenure decision - modeled by a minimum downpayment constraint on purchases of imperfectly divisible housing capital.

3.1. Housing tax provisions and benefits from homeownership

The link between tax code and the tenure decision as well as the financing decision of an individual is clarified below. The tenure and financing decision is self-evident when savings of the individual are not large enough to fulfill the downpayment constraint.

On the other hand, when savings are sufficient then both the minimum housing size and downpayment constraint (Equations (13) and (14)) are not binding. In this case a household prefers owning over renting, provided that the taxation of imputed rents is lower than the tax rate on other sources of capital income.

3.1.1. Tenure and financing decisions. Consider an individual with savings large enough to have the choice between owning and renting a home. Define h for now as the size of the home an individual would rent. The question now is to specify the benefit or cost an individual would face owner-occupying the same house. Given today's and tomorrow's net worth, the decision to become a homeowner increases the amount of owner-occupied housing by h units. This as a consequence increases the (implicit) capital income of the individual by $(1-\tau_{ir})(p-\delta_h)h$, where τ_{ir} is the tax rate on imputed rents, p is the price of one unit of housing services in terms of consumption and δ_h is the deprectiation rate of housing capital. For the case that housing can not be financed exclusively by the individual's net worth one has to pay mortgage interests net of deductibility accounting to $(1-\tau_y\tau_m)ib$, where τ_y is the tax rate on labor income and the return on financial assets, τ_m represents the deductible fraction of mortage interest payments from taxable income. Interest rate and amount of mortgage are denoted by i and b, respectively. But also the opportunity costs of housing investment have to be considered. Those correspond to the after-tax return on investment in financial assets of $(h-b)$ units, which is stated as $(1-\tau_y)i(h-b)$. Accordingly, after transformations and using the no-arbitrage constraint (Equation (19)), the net benefit from homeownership is given by

$$\pi(h,b;\omega) = \underbrace{[(1-\tau_{ir})ih-(1-\tau_y)ih]}_{\text{asset benefit}} - \underbrace{[(1-\tau_y\tau_m)ib-(1-\tau_y)ib]}_{\text{borrowing benefit/penalty}} \qquad (1)$$

where $\omega \in \Omega$ denotes a given policy arrangement.

The net benefit from owner-occupied housing is referred to as the asset benefit minus the borrowing penalty/benefit, whereby the asset benefit equals the opportunity cost of holding the asset subtracted from the implicit rental income from homeownership. This is the tax saving due to investing in housing instead of other financial assets. Obviously this is higher than zero as long as the tax rate on imputed rental income is lower than that on other income. The borrowing penalty is defined as the cost of the mortgage minus the opportunity cost of borrowing. Provided that mortgage interest is not fully deductible there is a borrowing penalty. Writing the penalty as $\tau_y(1-\tau_m)ib$ it is clear that the penalty would be zero in case of full mortgage interest deductibility ($\tau_m = 1$).

Under consideration of the definition of the equity fraction of the house as $\varphi \equiv$

$(h-b)/h$, another way of writing the net benefit of homeownership is

$$\pi(h,b;\omega) = [(\tau_y\tau_m - \tau_{ir}) + \varphi\tau_y(1-\tau_m)]ih. \tag{2}$$

Due to the restriction of the level of mortgage interest deductibility, the first term is positive when taxation of implicit rental income is lower than that of other kinds of income. As before, the second term is strictly positive except when $\tau_m = 1$. As a result, it can be noted that households with an adequate amount of savings strictly prefer owning over renting if $\tau_y > \tau_{ir}$. A second result can be derived from Equation (2). A higher equity fraction leads to more net benefit from owner occupied housing. This strictly increasing relationship leads to the fact that individuals that can overcome the downpayment constraint strictly prefer equity to debt. This is only the case when mortgage interest is not fully deductible, since otherwise ,if $\tau_m = 1$, equity is equivalent to debt. In the latter case, the benefit per unit of owner-occupied housing is the same for more and less wealthy households. This is the way in which deductibility of mortgage interest payments shows distributional effects. Further, this leads to the conclusion that the lack of taxation of imputed rents is the driving factor in explaining the rate of homeowners (Gervais, 2002).

3.1.2. Savings decision. Individuals have the possibility to increase their rate of return after taxation through investing in housing capital, only when the tax rate makes households prefer owning over renting. In this case, there is a wedge between the rates of return on housing capital and other financial assets. For a given h and b the return on savings is specified as

$$R(y;h,b) = \frac{(1-\tau_{ir})ih + (1-\tau_y)ia - (1-\tau_y\tau_m)ib}{y}, \tag{3}$$

where a is the amount invested in financial assets and net worth y is defined as $a+h-b$. Specifying $\tau_{ir} = 0$ and $\tau_m > 0$, individuals strongly tend to accumulate wealth as well as shifting more consumption to future periods in order to meet the downpayment constraint and receive the benefit from higher returns on housing capital. Furthermore, the preferential tax treatment of housing capital causes individuals to overconsume housing capital. From Equation (3), it is obvious that this is the case when $\tau_{ir} < \tau_y$. Then the rate of return on savings is increasing in h. An important finding is that by eliminating the deductibility of mortgage interest the difference between the two rates of return is significantly reduced.

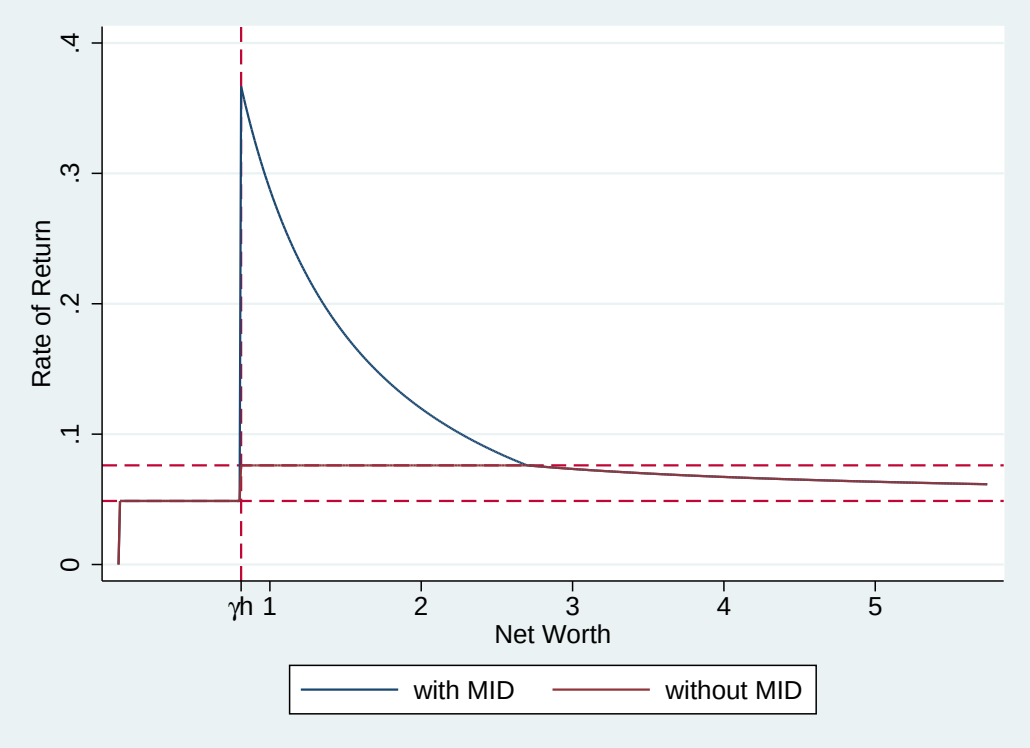

FIGURE 3. Rate of return on savings when $\tau_{ir} = 0$, with and without mortgage interest deductibility

In Figure 3 an optimal size of mortgage is assumed, which is minimal in the case with no mortgage interest deductibility (see second result in Section 3.1.1). As a result of this, individuals do not invest in financial assets as long as they are not free of debt. This leads to three stages in the return on savings: As long as savings are not sufficient to meet the downpayment constraint only financial assets are hold. After purchasing a house until the point when net worth is bigger than the house value, the rate of return on savings equals the interest rate i (housing equity is not taxed in this case). During the last stage the rate of return is a weighted average of both the return on housing and financial assets (Gervais, 2002).

4. Calibrating a Benchmark Model for Germany

This section illustrates the calibration of model parameters to the German economy and compares the results to those from Gervais (2002) for the U.S.[8] The calibrated parameters are given in Table 2.

8. Following Gervais (2002), numerical solving methods are applied to solve for a competitive equilibrium as defined in the Appendix. For the model implementation in MATLAB I used the Fortran code file (Gervais, 1999a) and the solution algorithm (Gervais, 1999b) that correspond to Gervais (2002).

Preferences	β	0.99
	θ	0.35
Technology	A	1.0172
	α	0.37
	$\underline{h}$	2.75
	$\underline{s}$	2.5
	δ_k	0.1
	δ_h	0.04
Tax system	τ_y	0.359
	τ_m	0
	τ_{ir}	0
Downpayment	γ	0.3

TABLE 2. Model parameters for the German economy

4.1. Demographics and labor income distribution

Identical to Gervais (2002), in the replicated model for Germany one period corresponds to one full year of an individuals lifetime. Furthermore, it is assumed that an individual lives for J=52 model periods. The retirement age in Germany is between 63 and 65 years[9]. Therefore, model period 41, corresponding to 64 years in reality, represents the retirement age. A new generation is assumed to be born in real-life at age 24, which corresponds to model period one and is expected to die at age 75, which corresponds to model period 52.

Survey data from the SOEP (2019) from the German Institute for Economic Research (DIW) is used to generate the labor income distribution for the five representative individuals. For this, the mean labor income of males for each labor income quintile at each age is calculated and normalized such that average income is equal to 1[10].

9. Starting 2012 until 2029 the retirement age is raised gradually from 65 to 67 or 63 to 65 depending on length and type of employment. Early entry into retirement is possible with deductions on the state pension (Deutsche Rentenversicherung, 2021).

10. I use annual individual labor earnings data from the years 2000-2015. First, I only use males with a positive labor income. Second, the remaining observations are sorted according to the variable age, earnings are adjusted for inflation by the CPI (Consumer Price Index) of the corresponding survey year and after that, earnings are assigned to the corresponding income quintiles for each age. In the last step, the mean labor income for each quintile at each age is built and normalized.

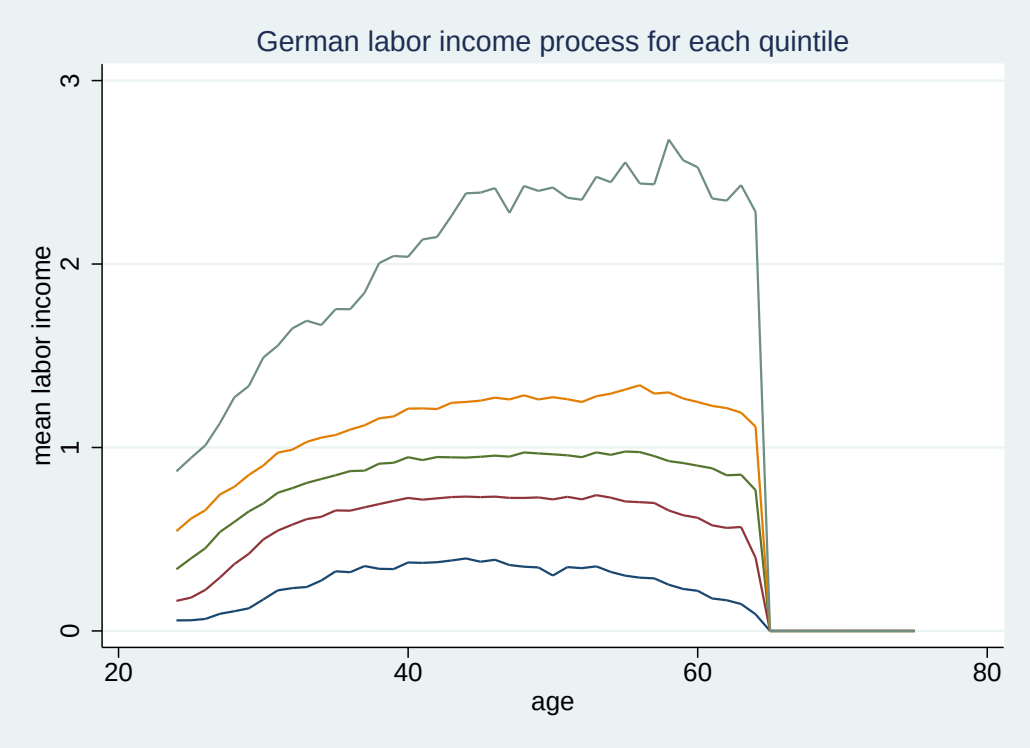

FIGURE 4. German labor income process for each quintile (SOEP v.34)

The (normalized) labor income profiles for five representative individuals (income quintiles) are shown in Figure 4. The German labor income distribution shows that the profiles for each quintile increases over life time until 5-10 years before retirement.[11]

4.2. Preferences

In line with Gervais (2002), the discount factor is calibrated such that the capital-output ratio equals 3.2, the target value from the data (Derbyshire et al., 2013). The resulting value of 0.99 for β coincides with Kaas et al. (2021) and Gadatsch et al. (2016).

θ represents the share of housing services in total expenditures. I set this parameter to reproduce a share of housing capital in total capital of around 47 percent (Schmalwasser and Schidlowski, 2006) in the benchmark model. In contrast to Gervais (2002), consumer durables will not be included into housing capital, since neither mortgage interest on housing nor mortgage interest on consumer durables are deductible from taxable income in Germany (Federal Ministry of Finance, 2019). Therefore, I believe that Gervais' justification that households take out bigger loans to finance their consumer durables as in the U.S. is not applicable to Germany. The resulting share of housing in total consumption expenditures, θ, of 35 percent matches with the share of housing in consumption expenditures on living, energy and

11. One could also include pension subsidies and other forms of income after retirement.

maintenance from 2010-2015 according to data from the German Federal Statistical Office (German Federal Statistical Office (Destatis), 2018).

4.3. Downpayment

In line with (Gervais, 2002), I calibrate the downpayment fraction by means of average Loan-to-Value Ratios (LTV) instead of targeting the LTV in the model. In Germany there is no regulatory maximum on the LTV ratio. Geiger et al. (2016) report that the LTVs in Germany are on average around 70 percent. Thus, I set the downpayment fraction of 30 percent in the benchmark model to meet the average LTV. This downpayment fraction coincides with suggested downpayment ratios (20-30%) of various German banks.

4.4. Technology

The section describes the calibration of the technology parameters $A, \alpha, \underline{h}, \underline{s}, \delta_h$ and δ_k.

δ_h is calibrated by Gervais (2002) as the weighted average of the depreciation rate of housing and consumer durables. To be consistent in the definition of housing capital the consumer durables will be excluded for Germany (Section 4.2). The depreciation rate for housing capital, i.e. residential capital in this case, is calibrated following Kollmann et al. (2015)[12]. It follows a depreciation rate of 0.04 p.a. for housing capital.

Gervais (2002) calculates a weighted average of the depreciation of business structures and producer durables to calibrate δ_k. Due to a lack of appropriate data on the depreciation of capital for Germany, δ_k is set according to values used in existing research. According to the calibration of Pariès and Notarpietro (2008) and Kollmann et al. (2015)[13], the depreciation rate of business capital δ_k is set equal to 0.1.

I calibrate the minimum housing sizes for owning and renting to pin down the homeownership rate of Germany. Niehues and Voigtländer (2016) state that since 2010 the homeownership rate is roughly constant at 45 percent. Other sources suggest a homeownership rate for Germany of slightly over 51 percent in 2015 (Eurostat, 2017). Therefore, the minimum housing sizes are calibrated in order to replicate an ownership rate of around 48 percent, which is the average of the two prevalent values.

The capital share in production is α. As the model assumes constant returns to scale, the production elasticity of the second input factor (L) denotes to $1 - \alpha$. For Germany and under the assumptions of constant returns to scale, α thus can

12. Where the quarterly depreciation rate for housing capital is set equal to 0.01.

13. They calibrate on the base of quarterly data, therefore the depreciation rate has to be annualized.

be calculated over the labor share (Havik et al., 2014). I calculate the labor share according to Meyer and Meyer (1994) as

$$LS = Comp \cdot \frac{ET}{EE} \cdot (VA), \tag{4}$$

where $Comp$ denotes the compensation of employees, ET the total employment, EE total employees and VA represents value added at current prices. Using OECD data from 2008-2016 from OECD (2017), I calculated a labor share of 0.63 and a resulting capital share of 0.37, which are the same values as in Havik et al. (2014). Therefore, α for Germany is set equal to 0.37.

Lastly, according to Gervais (2002) the technology level is calibrated in order to receive a wage rate at unity and to replicate the capital-output ratio found in the data. Derbyshire et al. (2013) find a capital-output ratio of 3.2 both for 1995 and 2002. Thus, I adjust A in order to approximate a capital-output ratio of 3.2.

4.5. Tax system

In the German taxation system, housing capital is not treated as preferential as in the U.S.. Mortgage interest payments from mortgages, which are secured against owner-occupied housing are not deductible from taxable income. Conversely, mortgage interest payments secured against residential capital, which is rented out, are deductible. But the latter is not considered within the model. Identical to the U.S. tax system, imputed rents are not taxed (European Comission, 2012; Johannesson-Linden and Gayer, 2012; Federal Ministry of Finance, 2019). Hence, in the benchmark model $\tau_m = 0$ and $\tau_{ir} = 0$.

The income tax rate τ_y is a proportional tax rate on labor income and the return on financial assets. The tax rate for income is calibrated according to Drygalla (2016), who calculated the tax rates for labor and capital according to Mendoza et al. (1994). The method of Mendoza et al. (1994) uses national account data and actual tax payments to calculate effective tax rates for macroeconomic models. An advantage compared to other calibration methods is the consideration of social security contributions as a form of income taxation in Mendoza et al. (1994). This is important as both taxes on wages and salaries as well as social security contributions constitute to the labor income tax in Germany.

However, Drygalla (2016) and Mendoza et al. (1994) calibrate separate tax rates for labor and capital income. In order to receive a combined tax rate for both capital income and labor income as in Gervais (2002), I proportionally combined the tax rates for capital and labor from Drygalla (2016) using data from the German Federal Statistical Office on disposable income from 1999 to 2012 (Statistisches Bundesamt (Destatis), 2017). I calculate the shares of taxable capital income and taxable labor

income in total taxable income to multiply each share with the corresponding tax rate. This procedure results in a tax rate τ_y of 0.359.

5. Results

5.1. Behavior in the benchmark model

The behavior of individuals in the benchmark model can be split into three groups of individuals. The upper class consisting only of quintile five, the middle class (quintiles 2-4) and the poorest income quintile. The poorest consume the smallest possible amount of housing services over their whole lifetime and thus never own a home. The lower middle class individuals start consuming the minimum amount of housing services in combination with a low consumption level of the composite good. Thus, they can save enough to become a homeowner at some point. At this point individuals are constrained by the minimum housing size. Therefore they move into the smallest possible house. Getting wealthier over the years, at least the richer individuals of the middle class move into bigger houses. Also the consumption of the upper class individuals is constrained when they are young. But unlike the individuals belonging to the middle class, upper class individuals are not constrained by the minimum size of housing services. As they can afford the downpayment after a few years, they first move into the largest house they can afford. As a result of getting wealthier during the next years, they are neither constrained by the minimum housing size nor the downpayment constraint. Thus, they increase both consumption and the size of the house they live in.

However, there are some differences in the outcomes for the U.S. generated by Gervais (2002). First, the tenure decision of purchasing a house is shifted backwards a few periods. Second, individuals tend to finance their home often without a mortgage and third, individuals in the poorest income quintile tend to consume non-positive amounts of the composite good in the first periods. The presumably main reason for outcomes one and two are the relatively high calibrated minimum housing sizes in order to replicate the low ownership rate of Germany. The calibration of the minimum housing sizes to target the owner-occupancy rate may be seen as a shortcoming of the model. Nevertheless, I think it is a good way to account for the indivisibility of housing. It appears that the purchase of houses by individuals is shifted backwards several years to replicate the lower homeownership rate in contrast to the U.S. economy. According to Kaas et al. (2021) this trend is partially consistent with the fact that in Germany households become homeowners later in the life-cycle. There is evidence that the homeownership in Germany increases between ages of below 35 and 66-75 around twice as much as in other comparable European countries (Kaas et al.,

2021). This coincides with a lower loan-to-value ratio for the German economy in this model. Households accumulate net worth over a longer time and thus may need a smaller mortgage to finance their home. A second reason is that, according to the German tax code, in the benchmark model for Germany mortgage interest payments are not deductible from taxable income. From result 2 in Section 3.1.1, one knows that equity is strictly preferred to debt. This in combination with the delayed tenure decision induces a smaller fraction of individuals to mortgage finance their home. The third outcome can be supported by the non-convexity gauged by minimum housing size constraints and tenure decision and does not, as one might think, reflect the behavior of non-maximizing individuals. As explained above the minimum size of housing services is higher for Germany. Since individuals need to consume at least the minimum amount of housing services individuals of the poorest income quintile behave optimal in the form that they consume the smallest amount of rented housing services possible. In order to be able to afford this amount in the current as well as in the following period, they need to save net worth for the following period and tend to consume a negative amount of the composite good until they get more productive and wealthier.

I would like to discuss further implications regarding the behavior in the benchmark model. Assets are accumulated by all individuals during their productive years in order to use them up for consumption during retirement period. Also, some individuals switch back to debt finance their house instead of holding the whole asset as equity, to ensure consumption of goods and housing services in the very last periods of their life. This coincides with the findings of Gervais (2002). As induced by the model itself, individuals do not hold financial assets while paying back their mortgage. The model is such that all individuals die with zero net worth with certainty.

Walras' law is satisfied for a tolerance level of 1E-5 and for a tolerance level of 1E-3 when negative consumption is eliminated, i.e. that negative consumption is set equal to zero before calculating the aggregate quantities. The business capital market is cleared at a tolerance level of 1E-6. The budget constraint is approximately zero for all individuals at all ages.

	Benchmark model	Experiment 1 ($\tau_m = 1$)	Experiment 2 ($\tau_{ir} = \tau_y$)
Quantities			
Total Output (Y)	1.221	1.215	1.276
Total capital	4.948	4.906	4.938
Business capital (K)	2.564	2.528	2.883
Total housing	2.384	2.378	2.055
Owner housing (H)	1.807	1.814	0.000
Rental housing (H^f)	0.577	0.563	2.055
Relative quantities			
Total capital/Y	3.301	3.281	3.316
K/(total capital)	0.518	0.515	0.584
$H/(H + H^f)$	0.758	0.763	0.000
G/Y	0.243	0.244	0.245
$(C + pX)/Y$	0.378	0.378	0.402
$pX/(pX + C)$	0.353	0.357	0.282
Prices			
i(%)	7.626	7.784	6.373
w	1.000	0.995	1.045
P	0.116	0.118	0.104
Homeownership rate	0.481	0.488	[0.0;0.0]
Income tax rate (τ_y)	0.359	0.362	0.326

TABLE 3. Statistics for the three tax codes

5.2. Experiments

To study the impact of the two existing forms of preferential tax treatment of housing in Germany, two revenue-neutral experiments are conducted. Revenue-neutral in this context means the assumption of constant remaining government expenditures, which are financed by the tax revenues even if fiscal policy is changing.

Following Gervais (2002), a welfare measure is specified in order to compare different fiscal policy arrangements. Usually an individual's welfare is defined as the lifetime utility, which is denoted by

$$W(\omega) \equiv \sum_{j=1}^{J} \beta^{j-1} u(c_j, x_j) \tag{5}$$

for a given fiscal policy $\omega \in \Omega$.

The difference in welfare between two different policies is denoted as κ. This is the value of consumption, as percentage of average lifetime consumption $\bar{c}$, that needs to be handed to a new born individual as compensation in every period of life, ensuring that it is indifferent between two policies. Thus, κ is defined such that

$$W(\omega_1) = W(\omega_2, \kappa) = \sum_{j=1}^{J} \beta^{j-1} u(c_j + \kappa\bar{c}, x_j). \tag{6}$$

One then has to search for the average lifetime consumption in the benchmark model that would be required as compensation to make the individual indifferent between the tax code in the experiment and the benchmark model. Below, Experiment

1 introduces mortgage interest deductibility and Experiment 2 removes all policy interventions that support preferential tax treatment of owner-occupied housing.

5.2.1. Experiment 1 - Introducing mortgage interest deductibility. In order to simulate the introduction of mortgage interest deductibility τ_m is set equal to 1. To maintain revenue neutrality, the income tax rate (τ_y) is adjusted to 0.3624.

Aggregate quantities: Overall, the introduction of mortgage interest deductibility has small distributional consequences. The deductibility of mortgage interest has no significant impact on the amount of housing capital. However, the relative advantage of owner-occupied housing has increased even more provided that downpayment and minimum housing size constraints do not bind. The difference between the rates of return on housing capital and other financial assets has also increased. As a result, the wedge in the rates of return on owner-occupied and rental housing increases the owner-occupied housing stock at the expense of a lower amount of rental housing capital. The homeownership rate increases by 0.7 percentage points.
The wedge influences households behavior in two ways, causing the homeownership rate to increase. First, households (especially those in the high income quintiles) ensure to meet the downpayment constraint earlier in life by reducing consumption of goods and housing services as well as by accumulating wealth more quickly. Second, individuals increase their debt financing, which in turn enables them to have higher consumption levels after buying a home as well as to buy larger houses. The average loan-to-value ratio increases by 31 percent from 3.82 percent to 5.55 percent. However, from Section 3.1.1 one knows that equity is equivalent to debt in this case.[14] Furthermore, the business capital stock decreases. And as one would expect the interest rate increases, since to maintain revenue neutrality the income tax rate has to be lifted, which creates a lower desire to save as disposable income shrinks.

While given the issues discussed in Section 5 the effects are significantly smaller in size the directions of the results are comparable to those found by Gervais (2002) for the U.S. economy.

Welfare effects: The welfare results for Experiment 1 are presented in Table 4 for each income quintile. The table shows the compensation in percent of the individuals average lifetime consumption in the benchmark model per period that would make the individual indifferent between the two tax codes. For Experiment 1 the results imply that consumption in the benchmark model could be lowered by on average

14. In Experiment 1 (with mortgage interest deductibility) individuals are indifferent between mortgage and equity. Thus the loan-to-value ratio is not well defined. The ratio is calculated under the assumption that individuals pay back their entire mortgage before they invest in financial assets again.

0.36 percent.[15] Thus, there are welfare losses due to introduction of mortgage interest deductibility. While the homeownership rate is increased, all income quintiles would nevertheless prefer to live in an economy without mortgage interest deduction. This results from the desire of individuals to smooth their consumption profile over life-time. In conclusion, incentivised by the introduction of MID, welfare losses occur as a consequence of over-accumulation of net worth to faster overcome the constraints towards homeownership.

	Consumption Compensation (%)
First quintile	0
Second quintile	0
Third quintile	-0.42
Fourth quintile	-0.36
Fifth quintile	-0.13

TABLE 4. Welfare effects Experiment 1 (Germany)

Distributional Consequences: Re-distributional effects can expected to be small given that a tax code without mortgage interest deductibility is preferred. Supporting the small re-distributional effects, the wealth GINI coefficient, a measure for wealth concentration, decreases by less than one percent from the Benchmark model to Experiment 1 (41.67 to 41.63 percent).

5.2.2. Experiment 2 - Taxing imputed rents. The second experiment evaluates the effects of removing all preferential tax treatment of owner-occupied housing. For this, the tax rate on imputed rental income is set equal to the income tax rate ($\tau_y = \tau_{ir}$). Both tax rates are adjusted to maintain revenue neutrality. The rate of mortgage interest deduction has to be set equal to 1. Otherwise individuals would not receive normal deduction.[16]

Aggregate quantities: From Table 3, one can see a crowding out effect from housing capital towards business capital due to the preferential tax treatment of housing compared to the benchmark model and Experiment 1. As in Experiment 2 no individual prefers owning strictly over renting, the ownership rate is not well defined. One can assume that every individual that is indifferent between owning and renting decides to own. Then, the homeownership rate remains zero for Experiment 2. This would suggest that homeowners in Germany own because of the tax code. Whether this is a meaningful result is left for discussion. Although this result is probably

15. Following Gervais (2002) this number is calculated by dividing the average compensation by the average life-time consumption.

16. Normal deduction is "defined as the deduction that would result if mortgage interest payments were in fact deductible against housing capital revenues instead of other types of income." (Gervais (2002)) Therefore the inequality $\tau_m >= \tau_{ir}/\tau_y$ has to be satisfied.

caused in part by the problems mentioned in Section 5, one can expect a significant number of homeowners to own because of the tax code. The taxation of imputed rents lowers the income tax rate by around 10 percent and therefore individuals dispose over substantially more income. This induces individuals to save more, resulting into a lower interest rate and in turn a higher stock of business capital. An important implication from this experiment is that now the rates of return on owner-occupied housing and business capital are equalized.

Welfare effects: Welfare results for Experiment 2 are presented in Table 5. For the second Experiment, welfare gains are identified compared to both the benchmark model and Experiment 1. Individuals from all quintiles experience welfare gains. To be indifferent between the benchmark model and Experiment 2, a per period consumption compensation of 3.63 percent of the benchmark models' average lifetime consumption would be required[17].

	Consumption Compensation (%) vs. Benchmark	Consumption Compensation (%) vs. Experiment 1
First quintile	0.47	0.83
Second quintile	1.27	1.56
Third quintile	3.28	3.5
Fourth quintile	2.27	2.52
Fifth quintile	1.92	1.96

Table 5. Welfare effects Experiment 2 (Germany)

Equal taxation of all sources of income implies that rates of return are equalized for owner-occupied housing and other forms of capital. Average rates of return on savings over the lifetime are illustrated for the different models in Figure 5. Under Experiment 1 - under mortgage interest deductibility - and to a smaller degree under the Benchmark model, individuals have the desire to accumulate savings faster at younger ages to become homeowners and thus receive a higher rate of return on savings. However, the incentive to overconsume housing is removed in Experiment 2, when the wedge between rates of return on owner-occupied housing and other assets is eliminated.

These findings coincide with the resulting consumption profiles (Figure 6). The evolution of the consumption bundle for Experiment 2 remains much flatter over time than for the other settings. Also, in contrast to Experiment 1 and the Benchmark model, younger individuals consume more when imputed rents are taxed since they do not tend to give up consumption in the first years to accumulate savings.

17. Again, this number is calculated by dividing the average compensation by the average life-time consumption.

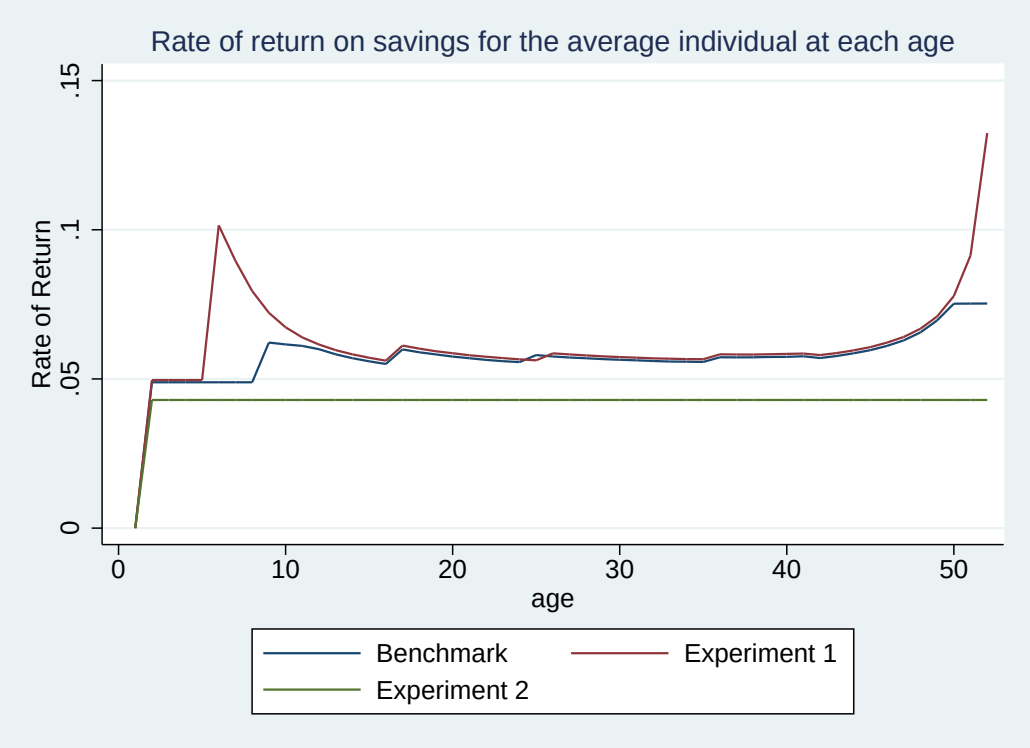

FIGURE 5. Rate of return on savings for the average individual at each age

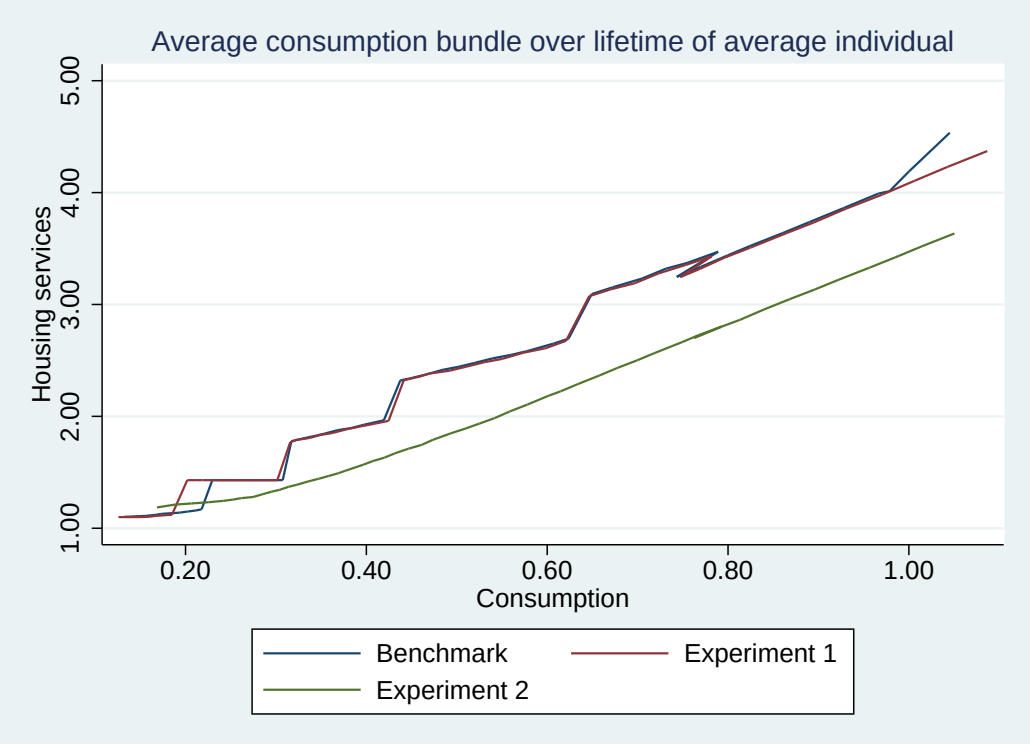

FIGURE 6. Average consumption bundle over lifetime of average individual

Consequently, the consumption profile is smoother both across time and consumption goods under Experiment 2.

Distributional Consequences: The GINI coefficient in Experiment 2 is 6.1 percent lower than in the benchmark model. In combination with the welfare results, this

suggests that individuals rather live in a world in which wealth is less concentrated among the rich.

5.3. Discussion of Results

This paper focuses on the relationship between tenure choice and tax code in a relatively simple model framework by Gervais (2002). Given the recent advances in literature on this topic the upcoming section aims to discuss some of the results in context of these advances and the underlying model's limitations.

First, the models' tax code assumes an average tax rate on income and capital instead of taking progressive income taxation into account. In light of Chambers et al. (2009)' results, I would expect the results for Germany to change in the following direction: With progressive income taxation and under the assumption of revenue neutrality, the marginal tax rate in the baseline model would be lower on average and for poorer individuals, while higher income households would likely have to pay higher taxes. On average, one would expect individuals to save less. Lower income quintiles increase savings while due to the higher tax burden high income households are forced to lower savings, housing capital and consumption of the composite good. As a result, interest rates should increase and average income decrease. In turn, this leads to a lower homeownership rate compared to an average tax rate. Moreover, one would expect the value of MID to increase with income and corresponding marginal tax rates (Sommer and Sullivan, 2018). According to Chambers et al. (2009), a less progressive income taxation reduces the effects of owner-occupied housing favoring tax codes. This suggests my results to be a lower bound.

Second, all rental housing is owned by financial institutions (i.e. the corporate sector) in the model. Equation (19) ensures that the rental price to interest ratio is fixed. In other words, the supply of rental units is totally elastic when rental prices change. The more dampened the change in rental price the lower the reactions in the household sector. As in this case all rental income is held by financial institutions, such effects are completely muted (Chambers et al., 2009).

Lastly, I would like to discuss redistribution channels that are muted by holding house prices fixed. An introduction of MID while holding house prices fixed reduces the cost of homeownership and increases marginal tax rates. I find a slight increase in homeownership rates as a result to the reduced user cost of housing. Sommer and Sullivan (2018) allow house prices to adjust. They find an increase in homeownership after eliminating MID. Two important mechanisms after the change in tax-code are in place that this paper abstracts from: First, falling house prices reduce downpayment requirements, which allows credit-constrained lower income households to become homeowners. Second, the lower house prices allow unconstrained homeowners to reduce mortgage debt and increase housing consumption.

6. Conclusion

Studying the effect of preferential tax treatment of housing capital in Germany, i.e. the impact of untaxed imputed rents and mortgage interest deductibility, the model emphasizes the importance of the relationship between tenure choice and tax policy. My results suggest that this interaction distorts the decisions of individuals over lifetime. The favorable tax code in the general equilibrium life-cycle framework with heterogeneous agents generates a wedge between the rate of return on housing capital and business capital. A downpayment constraint on non-divisible housing capital purchases ensures that individuals face a tenure decision. Although simulations of different tax codes reveal that distributional effects are relatively small, individuals would prefer to live in an economy with less preferential tax treatment of housing capital. Either removing mortgage interest deductibility or taxing imputed rents leads to significant gains of welfare in the long run perspective. Those gains arise for individuals in all income quintiles. Furthermore, both preferential treatments of housing capital have distorting impact on individual decisions. When imputed rents are not taxed, the rate of return on capital is higher the more housing capital is hold. This increases the incentive to become a homeowner and to overconsume housing. Mortgage interest deductibility amplifies this behavior, by making individuals indifferent between holding equity and debt. Overall, individuals prefer a tax code, where imputed rents are taxed or mortgage interest deduction would be removed. Results reveal that the findings of Gervais (2002) for the U.S. are similar for the German economy, but to a lesser extent as justified previously by inconvexities induced through minimum housing sizes. For the German economy, calibration of high minimum housing sizes is required to replicate the low homeownership rate.

Given that both eliminating mortgage interest deductibility and the taxation of imputed rents would result in higher welfare for Germany, would the introduction of such tax reform still be reasonable in order to promote homeownership? What implications should be taken from those results? While the introduction of mortgage interest deduction suggests an increase of the homeownership rate it leads to welfare losses for the economy in the long run compared to the benchmark model. The taxation of imputed rents improves welfare in the long-run. However, impacts on the homeownership rate are not clear in this case. Hence, both aggregate and wealth effects should be considered before implementing a new tax policy. Importantly, the motives behind the reform and corresponding effects on different subgroups of individuals have to be considered. According to Floetotto et al. (2016), the implementation of a tax on imputed rents primarily influences the richest income groups. Thus a tax reform towards the taxation of imputed rents in the first

place harms the richest individuals, whereas the elimination of mortgage interest deductibility primarily leads to losses in the middle-income groups.

7. Appendix

7.1. Model economy

7.1.1. Households. Overlapping generations of finite living individuals populate the model economy. Households gain utility from a consumption good which is composite and housing services. The utility function of an individual entering the economy is given by

$$\sum_{j=1}^{J} \beta^{j-1}(logc_j + \theta logx_j) \ , \beta > 0 \tag{7}$$

where c_j denotes consumption of the composite good, x_j the consumption of housing services of an individual of age j, β represents the time discount factor and an individuals' lifetime is J. The technology for housing capital and services is also part of the household's problem. Each individual has the possibility to either own or rent. In the case of owning, an agent receives housing services directly from its housing capital, where it is assumed that one unit of housing capital generates one unit of housing services ($x_j = h_j$). h_j denotes the units of housing capital of an agent of age j.

The tenure decision is constrained by a minimum downpayment rate γ of the value of the house an individual wants to purchase as well as by the minimum size of owner-occupied houses $\underline{h}$, which reflects that housing capital is not perfectly divisible. By borrowing against the house the remaining cost can be financed with a mortgage of amount b_j. Alternatively, an individual with insufficient wealth can circumvent those constraints if it decides to rent rather than own. Rented housing services are denoted by s_j, which are limited by a minimum amount of $\underline{s}$, where $\underline{s} < \underline{h}$. Therefore, the total amount of housing services is then characterized by $x_j = h_j + s_j$, reflecting that both types of housing services are perfect substitutes in consumption. The price of one unit of housing services regarding consumption is denoted as p. Furthermore it is assumed that housing capital depreciates at a rate of δ_h (units per unit of capital) per period. This assumption leads homeowners to incur a maintenance cost accounting to the amount of depreciation costs and ensures that their house never depreciates below the minimum level of house size.

Furthermore, the income dynamics on the households side need to be specified. As mentioned before each individuals' life lasts for J periods, consisting of both a working and a retirement period. The age of retirement is denoted by j^*. Agents differ intra- and intergenerational. They are endowed with one unit of working time each period of their life before retirement, which they supply and transform into z_j efficiency units of labor. A wage rate of w is paid for each efficient labor unit. Both the average productivity level and the population size are normalized to unity at every point in time.

Another way for individual agents to accumulate wealth is the holding of the three accessible assets: housing (net of mortgages), business capital equity and deposits at financial institutions. The rate of return of the latter two is equalized by a no-arbitrage condition. Therefore, the two assets are the same from a household's perspective and the sum of both assets is denoted by a_j.
The balance sheet of a household is summarized in Table 1, where a_j consists of deposits and capital equity:

Assets	Liabilities
Owner-occupied housing (h_j)	Mortgage (b_j)
Financial assets (a_j)	Net worth ($y_j = a_j + h_j - b_j$)

TABLE 6. Household's balance sheet (Gervais, 2002)

7.1.2. Financial Institutions. For simplification, all rental housing units are owned by financial institutions. This means that all housing held by agents coincides with owner-occupied housing. Furthermore, financial institutions play the intermediate role for all borrowing and lending.

7.1.3. Production technology. Output is produced following the Cobb-Douglas production technology:

$$f(K, N) = AK^{\alpha}N^{1-\alpha} \tag{8}$$

The variable K denotes the amount of business capital used for production, N is specified as the size of the working population and A is a technology parameter. It is possible to transform output goods free of costs into consumption or investment goods (residential and business). According to this, the price of all three types of goods will be equal and normalized to unity.

7.1.4. Structure of taxation. This section outlines the structure of taxation for the U.S. as in Gervais (2002) that is different to the tax code of the German economy. Since the impact of different fiscal policy arrangements is studied a tax code has to be established. In the model individuals can earn three types of income, whereby two types refer to capital income. Clearly, the remaining one is labor income. Capital income consists of interest payments produced by financial assets and imputed rents generated by housing capital. Thus, owner-occupied housing as a fixed asset is used to produce housing services and to generate imputed rents (OECD, 2007).
The tax code enables the government to tax three types of income as well as to deduct an arbitrary fraction of mortgage interest payments from taxable income. Instruments used for this are τ_y, the tax rate on the return on financial assets and labor income as well as τ_{ir}, representing the tax rate on imputed rents and τ_m as the deductible fraction from taxable income of mortgage interest payments.

7.1.5. Household's decision problem. Households are confronted both with intra- and intertemporal decisions. Those decisions take place simultaneously. First, in the intertemporal stage, they choose how much savings they transfer to the next period. Second, households decide intratemporally the amount of consumption of the composite good and housing services during the current period as well as last periods savings' composition (Gervais, 2002).

Since only one state variable, the net-worth of today or yesterday´s savings, is needed to describe individual j´s situation with productivity z_j the household's optimization problem is relatively simple. As there is no uncertainty, the amount of savings today is chosen being aware of the fact that it will be optimized tomorrow. Therefore, given net worth at age j, an individual chooses the net worth of next period in order to maximize future discounted utility and the problem is recursively formulated as

$$V_j(y_j; z_j) \equiv \max_{y_{j+1} \varepsilon \Gamma} \{G_j(y_j, y_{j+1}; z_j) + \beta V_{j+1}(y_{j+1}; z_{j+1})\} \tag{9}$$

where $V_j(y_j; z_j)$ is defined as the value of an individual behaving optimal from period j until J, entering period j with net worth y_j and productivity level z_j. Net worth of tomorrow is chosen from the feasible set Γ.

G_j is the return function of an individual of age j and is specified as the maximum achievable utility given its net worth of today and tomorrow which solves the intra-temporal problem:

$$G_j(y_j, y_{j+1}; z_j) \equiv \max_{(c_j, x_j, a_j, h_j, b_j)} \{lnc_j + \theta lnx_j\} \tag{10}$$

subject to

1. a budget constraint

$$c_j + px_j + y_{j+1} \leq (1 - \tau_y) z_j w + y_j + (1 - \tau_{ir})(p - \delta_h) h_j + (1 - \tau_y) i a_j - (1 - \tau_y \tau_m) i b_j \tag{11}$$

where

$$\begin{aligned} y_j &= a_j + h_j - b_j \\ x_j &= s_j + h_j \end{aligned} \tag{12}$$

2. housing constraints

$$\begin{aligned} h_j &\geq \underline{h} \\ s_j &\geq \underline{s} \end{aligned} \tag{13}$$

3. net worth constraints

$$\begin{aligned} y_j &\geq \gamma h_j \\ y_j &\geq h_j - b_j \end{aligned} \tag{14}$$

4. further contraints

$$c_j \geq 0, j = 1, 2, ..., J$$

$$z_j = 0, j \geq j^* \tag{15}$$

$$a_1 = h_1 = 0$$

The expenditures on consumption goods, housing services and the savings for the next period are stated on the left hand side of Equation (11). The revenues on the right side consist of after tax labor income, net worth as well as after tax imputed rents (net of depreciation) generated through owner-occupied housing, after-tax income on financial assets and the subtraction of the deductible fraction of mortgage payments. An interesting fact is that if $\tau_{ir} = 0$, housing services disappear from the budget constraint except for the maintenance cost. This basically means, homeowners pay themselves the rent by transferring money from one side of the budget constraint to the other. Housing constraints were explained before. The first net worth constraint simply derives from the downpayment requirement. The second net worth constraint ensures that financial assets are non-negative.

7.1.6. Financial institutions' decision problem. The financial institutions' problem is formulated in a simple two-period way. A new cohort is born every period. The institutions use the earnings from accepted deposits to issue loans and buy residential capital in the first period. In the second period of their "lives" they gain proceeds for rental accommodations as well as interests from issued loans to pay their interests on deposits. After that they sell their capital (undepreciated) to new financial institutions in the same period as they only exist for two periods.
It is assumed that the interest rate on loans issued is the same as the interest financial intermediaries pay on deposits.
Defining the amount of rental housing in period t as H_t^f, the total amount of deposits as D_t^f as well as the total amount of loans issued and the total amount of housing service provided as B_t^f and S_t^f, respectively, the new financial institutions´problem in period t is given as

$$\max_{(B_{t+1}^f, S_{t+1}^f, H_{t+1}^f, D_{t+1}^f)} (pS_{t+1}^f - \delta_h H_{t+1}^f + iB_{t+1}^f - iD_{t+1}^f) \tag{16}$$

subject to

$$H_{t+1}^f + B_{t+1}^f \leq D_{t+1}^f \tag{17}$$

$$S_{t+1}^f \leq H_{t+1}^f. \tag{18}$$

The first constraint ensures, that financial institutions can only dispose over the amount of deposits to buy residential capital and issue loans. The second constraint

states that they cannot provide more housing services than they dispose over residential capital. To make sure that financial intermediaries are indifferent between asset holdings and liabilities, the following no-arbitrage condition needs to be satisfied:

$$i = p - \delta_h \tag{19}$$

This guarantees that the maximization problem is well defined and in equilibrium financial institutions will make zero profits. (Gervais, 2002)

7.1.7. Definition of a competitive equilibrium. This definition is adopted from Gervais (2002). For a given set of tax rates $\Omega = \tau_y, \tau_{ir}, \tau_m$ a steady-state competitive equilibrium for a given set of policy is a set of:

1. Value functions $V_j(y_j; z_j)$
2. Individuals decision rules $c_j(y_j; z_j)$, $x_j(y_j; z_j)$, $a_j(y_j; z_j)$, $h_j(y_j; z_j)$, $b_j(y_j; z_j)$ for each age j=1,2,..,J
3. Age-dependent, time-invariant measure of agent types $\lambda_j(y_j; z_j)$
4. A set of relative prices p, i, w and
5. Aggregate quantities $G, Y, K, N, D^f, B^f, H^f, S^f$

such that

1. given prices and fiscal policy, individual decision rules solve the dynamic program given by (1)-(7);
2. inputs are priced competitively: $i = f_K(K, N) - \delta_k$ and $w = f_N(K, N)$;
3. given prices and the fiscal policy, D^f, B^f, H^f, S^f solves the financial institutions' problem ((8) and (9));
4. the goverment maintains a balanced budget every period

$$G = \sum_{j=1}^{J} \int_{\lambda_j} [\tau_y z_j w + \tau_y i a(y_j; z_j) + \tau_{ir} i h(y_j; z_j) - \tau_y \tau_m i b(y_j; z_j)] d\lambda_j(y_j; z_j),$$

5. markets clear:
   i) asset markets clear:

$$K = \sum_{j=1}^{J} \int_{\lambda_j} [a(y_j; z_j) - b(y_j; z_j)] d\lambda_j(y_j; z_j) - H^f$$

$$D^f = \sum_{j=1}^{J} \int_{\lambda_j} a(y_j; z_j) d\lambda_j(y_j; z_j) - K$$

$$B^f = \sum_{j=1}^{J} \int_{\lambda_j} b(y_j; z_j) d\lambda_j(y_j; z_j)$$

ii) the goods market clears:

$$f(K,N) = \sum_{j=1}^{J} \int_{\lambda_j} [c(y_j;z_j) + \delta_h h(y_j;z_j)] d\lambda_j(y_j;z_j) + \delta_k K + \delta_h H^f + G$$

iii) the rental market for housing services clears:

$$\sum_{j=1}^{J} \int_{\lambda_j} [x(y_j;z_j) + h(y_j;z_j)] d\lambda_j(y_j;z_j) = S^f = H^f.$$

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