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by

Johannes Schünemann and Timo Trimborn

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Boosting Taxes for Boasting about Houses: Status Concerns in the Housing Market [*]

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Abstract. There is empirical evidence that households use residential houses as status goods. Their visibility qualifies them as an excellent signaling device of the relative income and wealth position, in contrast to less visible financial assets. To this end we introduce a residential housing sector and status concerns for housing into a neoclassical framework. In the model, households derive utility from the absolute amount of housing and from comparing their stock of housing to a reference stock, which is composed of the current or past level of housing of their peers. We analyze how status concerns affect household behavior and find that they increase housing demand and labor supply. Furthermore, we find that status concerns exert a negative externality and elevate housing to inefficiently high levels. We derive a (state contingent) optimal tax that establishes the first-best allocation along the transition path and at the steady state. Calibrating the model to the US we quantify the optimal tax on residential housing to 1.8%. Introducing the optimal tax entails a considerable welfare gain of 0.29% measured in consumption equivalents.

Keywords: Status Concerns; Residential Housing; Optimal Taxation

JEL: E03; O10; D10; H21; R31

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[†] Corresponding author. University of Goettingen, Department of Economics, Platz der Goettinger Sieben 3, 37073 Goettingen, Germany; email: Johannes.Schuenemann@wiwi.uni-goettingen.de.

[‡] Vienna University of Technology, Institute of Statistics and Mathematical Methods in Economics, Wiedner Hauptstraße 8 / 105-3, 1040 Vienna, Austria; email: timo.trimborn@tuwien.ac.at.

1. Introduction

The fact that the well-being of individuals is not only determined by their own consumption, but also depends on their relative socio-economic status is nowadays well-established in the economics and psychological literature. Brain image evidence suggests that satisfaction of individuals is driven by both their own income, and by their income in comparison to other people (Fliessbach et al., 2007; Dohmen et at., 2011). There is also evidence from surveys that reported happiness is crucially affected by the relative income position. (see e.g. Di Tella et al., 2010, and Birdal and Ongan, 2016). Yet, the problem of signaling the own relative position and observing other people's relative position with respect to income or wealth remains a problem. Usually, individuals have little or no direct knowledge about income and wealth of other people, and can only infer it from observing behavior of their peers. In this paper we argue that residential housing serves as a natural mean to signal the relative income and wealth position or, in other words, that people use residential housing as a positional status good. The reason is that the level of the peer's housing is easily observable – in contrast to the peer's holdings of other assets like shares or bonds.

Our approach finds support by empirical evidence for the US that households indeed use residential houses as status goods. Bellet (2017) reports that households' housing satisfaction declines by 0.43% when their reference housing stock (i.e. the housing stock in the neighborhood) increases by 10% while leaving the own housing stock unchanged. He also finds that households respond to that increase in their reference stock by increasing their own housing stock by 1%. These findings indicate that utility of households is negatively affected by larger and more expensive houses in their neighborhood, and that housing exerts a negative externality.

House prices positively depend on the quality of surrounding houses and local amenities, among other characteristics, indicating that housing might also exhibit a positive externality. Rossi-Hansberg et al. (2010) find that an exogenous increase in the quality of houses, achieved by a government intervention, increases house prices for unaffected houses in the neighborhood. They conclude that the higher quality of affected houses amplifies positive housing externalities and therefore the willingness to pay for unaffected houses. The observation of positive and negative housing externalities can be reconciled: The quality of surrounding houses exerts a positive externality (as estimated by Rossi-Hansberg et al.), while the negative externality stems from the inferred income and wealth position when households compare the own stock of housing to that of the neighborhood. Given this context, Bellet (2017) estimates the combined (net) effect of positive and negative externalities on utility and concludes that the negative externality is dominating. Nonetheless, the negative externality does not necessarily exert a negative impact on house prices, because households might be willing to pay higher house prices in prestigious districts to signal a high relative income and wealth position.

We introduce housing as a status good into a macroeconomic model and investigate the implications for household behavior, macroeconomic aggregates, and the optimal taxation of residential housing. For this purpose we extend a representative agent, neoclassical model by endogenous labor supply and (owner-occupied) residential housing. Households derive utility from nondurable consumption, leisure, housing services, and status concerns, where we keep the utility function general and only require positive and diminishing marginal utility for each of the inputs. Housing services enter utility in two ways: First, the level of housing services affects utility ("joy from housing services"), and second, the relative amount of the housing stock in relation to a reference stock affects utility ("status concerns"). The second channel represents the status effect of housing. The reference stock is either the average current housing stock of peers ("keeping up with the Joneses"), or a weighted average of the peers' past housing stocks ("catching up with the Joneses").

In the macroeconomic literature status concerns have been introduced into neoclassical models in order to investigate the consequences for household behavior and macroeconomic performance (see e.g. Abel, 1990, 2003; Caroll et al., 2000; Alonso-Carrera et al., 2005; Alvarez-Cuadrado et al., 2004; Fisher and Heijdra, 2009; Fisher and Hof, 2000; García-Peñalosa and Turnovsky, 2008; Van Long and Shimomura, 2004; Wendner, 2010a, 2010b, 2011, 2015).[1] However, so far only status concerns with respect to nondurable consumption or financial wealth have been investigated. To our knowledge, this is the first study which introduces residential housing as a status good into a macroeconomic model. This is surprising as one would expect housing to be one of the best visible and thus most natural means to signal income and wealth (as compared to, for example, shares).

The existing literature has shown that status concerns from financial wealth affects the effective discount rate with which households discount future utility. The intuition is that households

[1]There are also a number of papers which investigate the interaction of externalities from status concerns with those from capital accumulation or endogenous R&D in endogenous growth models, see e.g. Corneo and Jeanne (1997, 2001), Futagami and Shibata (1998), Liu and Turnovsky (2005), Turnovsky and Monteiro (2007), Fisher and Hof (2008), Strulik (2015), Hof and Prettner (2016).

gain additional utility from saving due to status concerns and therefore discount future utility with a (negative) additional factor compared to the constant (standard) discount rate. Status concerns for consumption, on the other hand, affect the household's effective intertemporal elasticity of substitution, which is given by the elasticity of consumption in utility. Our results can be interpreted in the context of these findings because housing is an asset and a (durable) consumption good at the same time. Consequently, we find that status concerns for housing affect household choices through two channels. First, the marginal rate of substitution between nondurable consumption and housing is affected since status concerns alter the elasticity of housing in utility, taking into account the joy from housing services and status concerns. Second, status concerns have an impact on the effective discount rate. This impact, however, is only present when the economy grows and when the utility function is not additively separable.

We investigate how status concerns for housing affect household behavior and find that higher status concerns increase housing demand and decrease demand for nondurable consumption. Consequently, households also supply more labor if nondurable consumption and leisure are normal goods. In a parametrized version of the model we show that this also holds in general equilibrium. At the steady state, status concerns increase the stock of housing and decrease nondurable consumption. Households supply more labor in order to be able to afford the higher steady state stock of housing. We also show how capital accumulation is affected. At the steady state the capital stock increases since higher labor supply raises the marginal product of capital and hence households respond by saving more in terms of physical capital.

We calculate the social planner's solution and find that status concerns exert a negative external effect. In the market solution, households demand too much housing and supply too much labor. The intuition for this result is that households engage in a rat race. They wish to own a larger stock of housing compared to their peers in order to increase utility derived from status. But their peers respond in the same way and also increase their stock of housing such that in equilibrium nobody enjoys higher utility from status. In contrast to the social planner, households do not take into account that increasing their own stock of housing alters the average housing stock, nor do they consider the endogenous evolution of the reference stock. This causes the externality. We derive an optimal tax on housing that would internalize the external effect during the transition and at the steady state. We also show that the lion's share of the higher demand for housing motivated by status is inefficient and should be taxed away by the government.

Finally, we calibrate a parameterized version of the model to the US. We find that the optimal tax on the housing stock equals 1.8% at the steady state. Introducing the optimal tax during the transition and at the steady state entails a considerable welfare gain of 0.29%, measured in nondurable consumption equivalents. We also show that the welfare loss compared to the first-best policy is negligible if the constant steady state tax would be implemented already during the transition. This result might be of high relevance for policy makers as they might be constraint to set taxes at time-invariant levels. We conduct a sensitivity analysis of the welfare gain and the steady state tax with respect to preference parameters and the adjustment speed of the reference stock. We find that both the optimal tax and the welfare gain are insensitive to changes in these model parameters.

For the interpretation of the optimal tax it has to be considered that the tax refers only to residential structures and not to the land part of the house price. In the appendix we divide houses into land and residential structures and show that status concerns with respect to the land part of the house do not affect the allocation and hence exert no external effect. The reason is that land is a fixed factor and therefore, by construction, cannot be overaccumulated.

Our paper is also closely related to the literature on optimal housing taxation (Turnovsky and Okuyama, 1994; Skinner, 1996; Gervais, 2002; Nakajima, 2010; Eerola and Määttänen, 2013). Most of the papers focus on the different tax treatment of housing and firm capital in a general equilibrium framework. The main finding is that taxing housing capital at the same rate as physical capital would entail a welfare gain. Since none of the papers introduced status preferences for housing, there would be no overaccumulation of housing if both assets would be taxed at equal rates. We argue that overaccumulation can occur even when both assets are taxed at the same rate because of status preferences. Hence, our paper gives rise to increasing housing taxes even beyond the tax on capital. Most closely related to our study is probably the paper by Aronsson and Mannberg (2015). They introduce status preferences for housing into a partial equilibrium model and derive optimal taxes for capital and labor if housing taxes are not available for the government. They find that capital should be subsidized and labor be taxed at the margin to prevent overaccumulation of housing. However, since the analysis is restricted to the partial equilibrium the authors cannot distinguish between transition and steady state, and do not take into account general equilibrium repercussions.

Further, we acknowledge that, aside from residential housing, durable goods such as cars, bags, or yachts also serve as status goods that allow to signal high income and wealth. In fact, our theoretical model can be interpreted as including durable goods in general because residential housing and other durable goods enter the model in the same way. However, most households hold by far more residential housing compared to other durable goods.[2] This is in particular true for the representative household of the US, to which our model refers. We therefore focus in our paper on the role of residential housing as a status good.

The paper is organized as follows. The next Section introduces the model with a general utility function. In Section 3 we solve for the social planner's solution and derive the optimal tax rate. In Section 4 we parameterize the model and derive results for the steady state. Section 5 presents the quantitative analysis with a calibration to the US. Section 5 concludes.

2. The Model

The economy consists of households, final output producing firms, and construction firms. Households own financial assets and residential houses. Final output producing firms hire labor and capital to produce output with a neoclassical production technology. Construction firms convert one unit of final output into one unit of residential investment.

We assume that the accumulation of capital and residential houses both entail strictly convex adjustment costs to prevent instantaneous adjustment of capital and housing stocks. The empirical literature on adjustment costs has identified costs arising at the plant level if firms adjust the capital stock or investment (see e.g. Cooper and Haltiwanger, 2006, for a recent study). Similar costs have been found to emerge for residential construction (see Topel and Rosen, 1988). Following Iacoviello (2005), we assume that housing adjustment costs accrue at the household level. These costs can best be understood as additional cost that arise when sequential tasks have to be performed at one construction side in a tight time frame, or in other words, when the household's residential investment is high. This explains why marginal costs are increasing in residential investment per unit of time. We assume that capital adjustment costs accrue on

[2]It is estimated that the stock of residential housing in the US is of equal size as the capital stock, whereas the value of the remaining durable goods stock is much lower. (Iacoviello, 2010 and 2011)

the firm level. Introducing capital adjustment costs for households instead would yield exactly the same results but would complicate the household's maximization problem.

Households. The economy is populated by a continuum of households $(0,1)$ of mass one. Households enjoy utility from nondurable consumption c, leisure $1-\ell$, and durable consumption or housing d. Housing refers to owner occupied housing only. In addition, households enjoy utility (or disutility) by comparing their stock of owner occupied housing with a housing reference stock H of the economy. Specifically, we assume that individuals draw utility from status $d/H \equiv z$. As we will show below, the reference stock may reflect either the past or the current average housing stock of the economy, depending on the adjustment speed of the reference stock. Households maximize

$$\int_0^\infty u(c,d,z,\ell)e^{-\rho t}dt \tag{1}$$

where ρ denotes the time preference rate. The utility function $u(\cdot)$ is assumed to have positive and diminishing marginal returns with respect to each of the inputs c, d, z, and $1-\ell$. Households receive labor income $w\ell$ and capital income ra. They spend their income for consumption of nondurables and residential investment in owner occupied housing x. For each unit of x households face strictly concave adjustment costs $\psi(x)$ so that for increasing the housing stock by x units total residential expenditures amount to $x(1+\psi(x))$. Adjustment costs and marginal adjustment costs are normalized to zero at the steady state. The budget constraint reads

$$\dot{a} = w\ell + ra - c - x(1+\psi(x)). \tag{2}$$

Durable goods depreciate at rate δ_d. Thus the stock of housing evolves according to

$$\dot{d} = x - \delta_d d. \tag{3}$$

Furthermore, the reference stock of households' housing consumption H adjusts according to

$$\dot{H} = \theta(\bar{d} - H) \tag{4}$$

where $\bar{d}$ denotes the economy's current average stock of housing, i.e. $\bar{d} = \int_0^1 d\,\mathrm{d}i$. Since households' choices of d have no impact on $\bar{d}$ and, hence, on H, they take the evolution of H exogenous. Our modeling of status concerns as adjusting reference stock is inspired by the habit formation literature (e.g. Carroll et al., 2000). This way of modeling also refers to what is known in the literature as "catching up with the Joneses". Note that for $\theta \to \infty$, $H \to \bar{d}$ for all t. In this setting, the reference stock adjusts infinitely quickly so that people directly compare their stock of housing to the current economy's average stock of housing. Hence our model is also able to capture the case of "keeping up with the Joneses". By deriving the optimal solution of the social planner in the next section, we show that not internalizing the evolution of the reference stock entails an external effect.

The Hamiltonian of the maximization problem reads

$$\mathcal{H} = u(c, d, z, \ell) + \lambda(w\ell + ra - c - x(1 + \psi(x)) + \mu(x - \delta_d d). \tag{5}$$

where λ and μ denote shadow prices of assets and housing, respectively. First-order conditions are given by

$$\frac{\partial \mathcal{H}}{\partial c} = 0 \quad \Rightarrow \quad u_c(c, d, z, \ell) = \lambda \tag{6a}$$

$$\frac{\partial \mathcal{H}}{\partial x} = 0 \quad \Rightarrow \quad (1 + \psi(x) + x\psi'(x))\lambda = \mu \tag{6b}$$

$$\frac{\partial \mathcal{H}}{\partial \ell} = 0 \quad \Rightarrow \quad u_\ell(c, d, z, \ell) = -\lambda w \tag{6c}$$

$$\frac{\partial \mathcal{H}}{\partial a} = \rho\lambda - \dot{\lambda} \quad \Rightarrow \quad \lambda r = \rho\lambda - \dot{\lambda} \tag{6d}$$

$$\frac{\partial \mathcal{H}}{\partial d} = \rho\mu - \dot{\mu} \quad \Rightarrow \quad u_d(c, d, z, \ell) + u_z(c, d, z, \ell)\frac{\partial z}{\partial d} - \mu\delta_d = \rho\mu - \dot{\mu} \tag{6e}$$

$$\lim_{t\to\infty} e^{-\rho t}\lambda a = 0 \qquad \lim_{t\to\infty} e^{-\rho t}\mu d = 0 \tag{6f}$$

Log-differentiating (6a) with respect to time and using (6d) yields the Euler equation for consumption growth

$$\frac{\dot{c}}{c} = \frac{r - \rho_e}{\sigma_e} \tag{7}$$

with

$$\sigma_e = -c\frac{u_{cc}(c, d, z, \ell)}{u_c(c, d, z, \ell)}, \qquad \rho_e = \rho - \frac{u_{cd}(c, d, z, \ell)\dot{d} + u_{cz}(c, d, z, \ell)\dot{z} + u_{cl}(c, d, z, \ell)\dot{\ell}}{u_c(c, d, z, \ell)}$$

being the effective intertemporal elasticity of substitution and the effective time preference, respectively. In order to give an intuition for the Euler equation, assume that, for example, the cross derivative of the utility function with respect to nondurable consumption c and housing

d is positive ($u_{cd}(c,d,z,\ell) > 0$). This would mean that the marginal utility of consumption is increasing in the housing stock. In case the housing stock is increasing over time ($\dot{d} > 0$), the Euler equation implies that consumption growth is higher as individuals tend to substitute present for future consumption when the housing stock is larger. If d, z, and ℓ are additively separable to consumption in the utility function (i.e. the respective cross derivatives turn zero), whether consumption rises or falls over time depends only on the relative size of the interest rate and the discount factor as in the standard Ramsey model. In other words, $\rho_e = \rho$ holds.

From (6a) and (6c) we obtain an optimality condition equating the wage rate to the marginal rate of substitution between nondurable consumption and leisure,

$$w = -\frac{u_\ell(c,d,z,\ell)}{u_c(c,d,z,\ell)} \equiv MRS_{\ell c}. \tag{8}$$

Further note that (6b) can be written as $p_x \lambda = \mu$ where $p_x \equiv 1+\psi(x)+x\psi'(x)$ denotes the relative price for one unit of installed residential investment in terms of final output. Intuitively p_x can be interpreted as the total increase in residential expenditure following a one-unit increase in x. Stated differently, $p_x = \frac{\mu}{\lambda}$. Since the shadow price of housing μ measures the price of another unit of d in terms of "utils" and the shadow price of assets λ measures the price of another unit of assets in terms of "utils", p_x represents the relative price of installed residential investment in terms of assets or final output.

Dividing (6e) by μ and using (6b) and (6a) gives

$$\begin{aligned} \underbrace{\rho - \frac{\dot{\lambda}}{\lambda}}_{r} - \frac{\dot{p}_x}{p_x} &= \frac{u_d(c,d,z,\ell) + u_z(c,d,z,\ell)\frac{\partial z}{\partial d}}{p_x u_c(c,d,z,\ell)} - \delta_d \\ \Leftrightarrow \quad p_x(r+\delta_d) - \dot{p}_x &= \frac{u_d(c,d,z,\ell) + u_z(c,d,z,\ell)\frac{\partial z}{\partial d}}{u_c(c,d,z,\ell)} \equiv MRS_{dc}. \end{aligned} \tag{9}$$

Since housing serves both as a consumption good and an asset, we can interpret this optimality condition in two ways. From the viewpoint of a consumption good, the condition equates the relative price of one unit of housing to the marginal rate of substitution between housing and nondurable consumption. The opportunity costs of one unit of housing in terms of nondurable consumption on the LHS increases in the forgone consumption goods that could have been purchased instead of investing in housing, $p_x(r+\delta_d)$, and falls following price increases in houses, $\dot{p}_x$. Note that the marginal utility from housing in the numerator on the RHS includes the additional effect of another unit of housing on utility that is triggered by improving relative to others (second term).

Treating housing as an asset, the equation can be also interpreted as a no-arbitrage condition. To see this the equation can be rearranged to $r = MRS_{dc}/p_x + \dot{p_x}/p_x - \delta_d$. The gain of investing one more unit in financial capital, r, must be equal to the gain of investing in housing which is given by the marginal rate of substitution converted into final goods with price p_x, and the growth rate of house prices net of depreciation.

We first would like to carve out how status preferences affect household consumption and savings decisions. To this end we compare a household with status concerns to a household without, and derive conditions under which the behavior would be the same. These conditions show how a household with status concerns behaves using the metric of a standard household without status concerns. For this comparison we focus on the "keeping up with the Joneses" case, i.e. we set $\theta \to \infty$, since otherwise the two economies would exhibit a different set of state variables.

Fisher and Hof (2000) derive conditions under which economies with status preferences with respect to nondurable consumption are observationally equivalent to status-free economies. They find that status economies exhibit an adjusted, or in other words, "effective" elasticity of utility with respect to nondurable consumption and conclude that the decentralized solutions are the same for status and status-free economies if this effective elasticity coincides with the "standard" elasticity of utility of the status-free economy. Likewise, Fisher and Hof (2008) show analogously that under relative wealth preferences status and status-free economies behave the same if the effective time preference rate of the status economy equals the one of the standard Ramsey model. Since housing is both a consumption good and an asset one would expect that observational equivalence requires conditions on consumption preferences as well as the discount factor to be fulfilled. We derive expressions analogous to (7)-(9) for the status-free economy obtaining

$$\frac{\dot{c}}{c} = \frac{r - \tilde{\rho}_e}{\tilde{\sigma}_e} \tag{10}$$

with

$$\tilde{\sigma}_e = -c\frac{\tilde{u}_{cc}(c,d,\ell)}{\tilde{u}_c(c,d,\ell)}, \qquad \tilde{\rho}_e = \rho - \frac{\tilde{u}_{cd}(c,d,\ell)\dot{d} + \tilde{u}_{cl}(c,d,\ell)\dot{\ell}}{\tilde{u}_c(c,d,\ell)}$$

and

$$w = -\frac{\tilde{u}_\ell(c,d,\ell)}{\tilde{u}_c(c,d,\ell)} \equiv \widetilde{MRS}_{\ell c} \tag{11}$$

$$p_x(r+\delta_d) - \dot{p}_x = \frac{\tilde{u}_d(c,d,\ell)}{\tilde{u}_c(c,d,\ell)} \equiv \widetilde{MRS}_{dc}. \tag{12}$$

In order to compare these conditions with equations (7) and (9) one should bear in mind that we focus on the "keeping up with the Joneses" case in which $z = d/\bar{d} = 1$ holds. Both types of households behave the same if $\rho_e = \tilde{\rho}_e$, $\sigma_e = \tilde{\sigma}_e$, $MRS_{cl} = \widetilde{MRS}_{cl}$, and $MRS_{dc} = \widetilde{MRS}_{dc}$ holds. In other words, consider a household which does not have status concerns, but discounts future utility with ρ_e and chooses nondurable housing and consumption according to MRS_{dc}. Then this household would be observationally equivalent to the household with status concerns.

Since status concerns increase the marginal rate of substitution for consumption and housing, they increase housing demand and decrease demand for nondurable consumption, ceteris paribus. If housing, leisure and nondurable consumption are normal goods, higher status concerns also increase labor supply. We will show for the parameterized version below that these results do not only hold for the households, but also for the general equilibrium.

Construction firms. There exists a continuum $(0,1)$ of construction firms producing residential investment goods. These firms convert one unit of final output into one unit of residential investment under perfect competition.

Final output producing firms. There exists a continuum $(0,1)$ of final output producing firms. Each firm employs capital k and labor L and produces with a neoclassical production function $y = f(k,L)$. The capital stock is owned by the firm and depreciates with rate δ_k. Firms have to pay strictly convex adjustment costs $\phi(i/k)$ per unit of installed capital. We normalize adjustment costs and marginal adjustment costs to zero at the steady state such that $\phi(\delta_k) = 0$ and $\phi'(\delta_k) = 0$ holds.

Firms maximize over investment, i, and labor, L, to maximize

$$\int_0^\infty \left[Af(k,L) - w\ell - i - k\phi\left(\frac{i}{k}\right)\right] e^{-\int_0^t r(s)ds} dt \tag{13}$$

subject to

$$\dot{k} = i - \delta_k k. \tag{14}$$

First-order conditions are

$$w = \frac{\partial f(k, L)}{\partial L} \tag{15}$$

$$q = 1 + \phi' \left(\frac{i}{k} \right) \tag{16}$$

$$\dot{q} = (r + \delta_k)q - \frac{\partial f(k, L)}{\partial k} + \phi \left(\frac{i}{k} \right) - \left(\frac{i}{k} \right) \phi' \left(\frac{i}{k} \right) . \tag{17}$$

General Equilibrium. Having set up the model in the last section, we will now define the general equilibrium of the economy. We assume that all households are identical.

Definition 1. *A symmetric general equilibrium consists of time paths for the quantities* $\{d, a, H, k, L, \ell, c, x, i\}_t^\infty$, *factor prices* $\{r, w\}_t^\infty$, *and shadow price* $\{q\}_t^\infty$ *such that*

(1) $d = \bar{d}$ *for all* t,

(2) *households maximize intertemporal welfare (1),*

(3) *final goods producers maximize profits, i.e. (15), (16), and (17) hold,*

(4) *construction firms maximize profits,*

(5) *the capital market equilibrium condition* $a = qk$ *holds,*

(6) *the labor market equilibrium condition* $\ell = L$ *holds, and*

(7) *the goods market equilibrium condition* $y = c + i + x + k\phi(i/k) + x\psi(x/d)$ *holds.*

The evolution of capital in the economy can thus be summarized by

$$\dot{k} = f(k, \ell) - c - x - \delta_k k - k\phi(i/k) - x\psi(x). \tag{18}$$

For convenience, we collect the equations that describe the evolution of the economy over time:

$$\dot{k} = f(k, \ell) - c - x - \delta_k k - k\phi(i/k) - x\psi(x) \tag{19a}$$

$$\dot{d} = x - \delta_d d \tag{19b}$$

$$\dot{H} = \theta(\bar{d} - H) \tag{19c}$$

$$\frac{\dot{c}}{c} = \frac{r - \rho_e}{\sigma_e} \tag{19d}$$

$$w = -\frac{u_\ell(c, d, z, \ell)}{u_c(c, d, z, \ell)} \tag{19e}$$

$$r + \delta_d = \frac{u_d(c, d, z, \ell) + u_z(c, d, z, \ell)\frac{\partial z}{\partial d}}{u_c(c, d, z, \ell)} \tag{19f}$$

$$p_x = 1 + \psi(x) + x\psi'(x) \tag{19g}$$

$$w = \frac{\partial f(k,\ell)}{\partial \ell} \tag{19h}$$

$$q = 1 + \phi'\left(\frac{i}{k}\right) \tag{19i}$$

$$\dot{q} = (r+\delta_k)q - \frac{\partial f(k,\ell)}{\partial k} + \phi\left(\frac{i}{k}\right) - \left(\frac{i}{k}\right)\phi'\left(\frac{i}{k}\right) \tag{19j}$$

together with the initial conditions $k(0) = k_0$, $d(0) = d_0$, and $H(0) = H_0$.

Steady State. We assume, and verify numerically below, that the system exhibits a unique interior steady state, which is saddle-point stable. At the steady state all aggregates are constant. This implies that in the steady state the capital-labor ratio is pinned down by the households' discount rate since $\rho = r$ must hold, i.e.

$$\rho = r = f'(k/\ell) - \delta_k \tag{20}$$

and hence the wage rate is given as well. Note further that from $\dot{H} = 0$, $\bar{d} = H$ and thus, applying symmetry, $d = H$. Since adjustment costs and marginal adjustment costs are normalized to zero at the steady state, p_x is constant and equal to 1. Our main equation of interest (9) at the steady state thus reads

$$\rho + \delta_d = \frac{u_d(c,d,1,\ell) + u_z(c,d,1,\ell)\frac{\partial z}{\partial d}}{u_c(c,d,1,\ell)} \tag{21}$$

where we have used that $z = \frac{d}{H} = 1$.

3. Negative Externalities and Optimal Taxation

Social planner's solution. In order to analyze whether status exhibits an externality we next derive the social planner optimum. Contrary to the households, the social planner takes the evolution of the reference stock of housing into account, and that the representative household's choice of housing d equals the average housing stock in the economy $\bar{d}$. In other words, the social planner internalizes the effect that household decisions have on the evolution of the reference stock in the economy. The social planner maximizes

$$\int_0^\infty u(c,d,z,\ell)e^{-\rho t}dt \tag{22}$$

subject to $\dot{k}$, $\dot{d}$, $\dot{H}$, with $d = \bar{d}$ and the goods market equilibrium condition. The Hamiltonian is given by

$$\mathcal{H} = u(c,d,z,\ell) + \tilde{q}(i - \delta_k k) + \mu(x - \delta_d d) + \eta\theta(\bar{d} - H) + \lambda\left(f(k,\ell) - c - i - x - k\phi\left(\frac{i}{k}\right) - x\psi(x)\right) \tag{23}$$

where $\tilde{q}$ represents the shadow price of capital and η denotes the shadow price of the reference stock. Summarizing the first-order conditions as presented above yields

$$\frac{\dot{c}}{c} = \frac{r - \rho_e}{\sigma_e} \tag{24}$$

with

$$\sigma_e = -c\frac{u_{cc}(c,d,z,\ell)}{u_c(c,d,z,\ell)}, \qquad \rho_e = \rho - \frac{u_{cd}(c,d,z,\ell)\dot{d} + u_{cz}(c,d,z,\ell)\dot{z} + u_{cl}(c,d,z,\ell)\dot{\ell}}{u_c(c,d,z,\ell)},$$

$$\frac{\partial f(k,\ell)}{\partial \ell} = -\frac{\tilde{u}_\ell(c,d,\ell)}{\tilde{u}_c(c,d,\ell)} \equiv \widetilde{MRS}_{\ell c} \tag{25}$$

$$p_x(r + \delta_d) - \dot{p}_x = \frac{u_d(c,d,z,\ell) + u_z(c,d,z,\ell)\frac{\partial z}{\partial d} + \eta\theta}{u_c(c,d,z,\ell)} \tag{26}$$

$$\dot{\eta} = \eta(\rho + \theta) - u_z(c,d,z,\ell)\frac{\partial z}{\partial H} \tag{27}$$

where p_x and r are defined as for the market solution. Note that the last equation represents the flow equation for the shadow price of the reference stock. We provide a proof of Equations (24) and (26) in the Appendix. Comparing the optimality conditions to the counterpart of the decentralized economy shows that equations (24) and (25) are the same as in the market solution. For the latter recall that in the market solution $w = \frac{\partial f(k,\ell)}{\partial \ell}$ holds according to Equation (19h). Only equation (26) differs to the market solution by $\eta\theta$. Note that if the reference stock does not adjust to the average stock of housing, i.e. if $\theta = 0$, the market solution and the social optimum coincide. Focusing on the steady state ($\dot{\eta} = 0$) we can derive a simple expression for η given by

$$\eta = \frac{u_z(c,d,1,\ell)\frac{\partial z}{\partial H}}{(\rho + \theta)}. \tag{28}$$

Applying the steady state conditions from above and using that $\frac{\partial z}{\partial H} = -\frac{d}{H^2} = -\frac{1}{d} = -\frac{\partial z}{\partial d}$ applies in the steady state, the optimality condition (26) can be written as

$$\rho + \delta_d = \frac{u_d(c, d, 1, \ell) + \frac{1}{d} u_z(c, d, 1, \ell) \left(1 - \frac{\theta}{\theta + \rho}\right)}{u_c(c, d, 1, \ell)}. \tag{29}$$

Notice that housing status does not have any effect on the social planner's optimal solution in the steady state if the reference stock adjusts infinitely quickly to average housing of the economy, i.e. if $\theta \to \infty$ and thus $\frac{\theta}{\theta+\rho} \to 1$. This means that in the case of "keeping up with the Joneses", the entire change in housing demand in the steady state triggered by status concerns is inefficient. If the economy is described by "catching up with the Joneses", only part of the change in housing demand due to status concerns is inefficient, and this part is increasing in the adjustment speed θ and decreasing in the discount rate ρ.

The intuition for this result with respect to θ can best be understood by first inspecting the limiting case of $\theta = 0$. In this case, the reference stock does not adjust and the social planner's solution would coincide with the market solution, i.e. status concerns would not cause an externality. The reason is that additional housing demand caused by status would indeed increase household utility, because in this case the reference stock does not respond to a larger housing stock. In the intermediate case of $0 < \theta < \infty$ the reference stock responds with a delay to the average housing stock of the economy. Hence, when the representative household increases housing by one unit, it enjoys utility from status immediately just as in the case of $\theta = 0$. However, the reference stock adjusts over time and converges towards his housing stock driving his utility premium from status down to zero. The household does not take into account that his own higher housing stock causes the adjustment which, in the end, causes the external effect. The higher θ the faster is the adjustment, and hence the larger is the fraction of status demand which is inefficient.

Having this in mind it is now straightforward how the household's discount rate ρ affects the fraction of housing demand which is inefficient. With a larger ρ, households discount future instantaneous utility with a higher rate and immediate gratification has a higher impact on household behavior. Therefore, with a larger ρ the distant future at which the reference stock adjusts and nullifies utility from status concerns has less weight for the household (and likewise for the social planner), which decreases the fraction of status demand that is inefficient.

Optimal Taxation. Since the market solution is socially inefficient, we derive the optimal tax rate on housing wealth that internalizes the externality caused by status concerns. For this purpose, we introduce the tax rate τ on the stock of residential housing into the budget constraint as follows:

$$\dot{a} = w\ell + ra - c - p_x x - \tau d + T. \tag{30}$$

The tax income is redistributed to the households by a lump sum transfer T. Hence, the government budget reads $\tau d = T$. We now recalculate the market solution. Equation (9) is then modified to

$$p_x(r + \delta_d) - \dot{p}_x = \frac{u_d(c,d,z,\ell) + u_z(c,d,z,\ell)\frac{\partial z}{\partial d}}{u_c(c,d,z,\ell)} - \tau. \tag{31}$$

The optimal tax rate can be determined by comparing this optimality condition to its counterpart of the social planner's solution in (26).[3] For the case of $\theta < \infty$ the resulting optimal tax rate is thus given by

$$\tau^* = -\frac{\eta\theta}{u_c(c,d,z,\ell)}. \tag{32}$$

Focusing on the steady state,

$$\tau^*_{SS} = \frac{\theta}{d(\rho+\theta)} \frac{u_z(c,d,1,\ell)}{u_c(c,d,z,\ell)}. \tag{33}$$

For the case of $\theta \to \infty$ the optimal tax is

$$\tau^* = \frac{1}{d} \frac{u_z(c,d,1,\ell)}{u_c(c,d,1,\ell)} \tag{34}$$

at the transition and at the steady state. In both cases the optimal tax is positive on the transition path and at the steady state, implying that housing demand in the decentralized economy is too high. Multiplying the tax rate by d gives the total tax payments that the household has to incur. Note that dividing u_z by u_c converts the extra utility from status in monetary equivalents. Intuitively, at the steady state households are charged the extra utility from status expressed in \$'s weighted by the size of the external effect which is determined by $\frac{\theta}{\theta+\rho}$. In case $\theta \to \infty$ all of the higher housing demand induced by status is socially inefficient so that households have to "pay back" all of their monetary extra gain from status.

[3]Grossmann et al., 2013, use a similar procedur to derive the optimal policy.

Recall from the social planner solution that we showed already how the size of the externality in the steady state depends on the model parameters θ and ρ. We can illustrate these model mechanics also by comparing the steady state tax τ^*_{SS} to the tax rate τ^a_{SS} that would absorb the additional demand induced by status completely. This tax rate can be deduced from (31). After applying the steady state conditions the tax rate can be written as

$$\tau^a_{SS} = \frac{1}{d}\frac{u_z(c,d,1,\ell)}{u_c(c,d,1,\ell)} \tag{35}$$

where we have used that $\frac{\partial z}{\partial d} = \frac{1}{d}$. Since $d = H$ holds in the steady state, we can now measure the fraction of inefficient demand by

$$\frac{\tau^*_{SS}}{\tau^a_{SS}} = \frac{\theta}{\theta + \rho}. \tag{36}$$

If this ratio equals 1, all demand induced by status is considered socially inefficient. Again this is the case for $\theta \to \infty$. As we will argue below in the calibration section, θ is expected to be much higher than ρ. Since the socially inefficient share of housing demand induced by status increases in the relative size of θ and ρ, we expect the externality from status to be large as well.

4. Parametrization

In this section, we set up a parameterized version of the model presented above. For this purpose we assume that households feature an additively separable utility function. This enables us to calculate the impact of status concerns on economic aggregates analytically. Of course, this shuts down the possibility that, for example, leisure has a positive impact on the marginal utility of housing (because households need leisure time to enjoy their dwelling). We argue below that this is probably only a second order effect and thus has only a dampening impact on the quantitative results but would not change the direction of the effect of status.

Households. Individuals maximize the following expression of life-time utility

$$\int_0^\infty \left(\frac{c^{1-\sigma_c} - 1}{1-\sigma_c} + \beta \frac{d^{1-\sigma_d} - 1}{1-\sigma_d} + \gamma \frac{1}{1-\sigma_H}\left[\left(\frac{d}{H}\right)^{1-\sigma_H} - 1 \right] + \kappa \frac{(1-\ell)^{1-\sigma_\ell} - 1}{1-\sigma_\ell} \right) e^{-\rho t} dt \tag{37}$$

Equations (7)-(9) can be written as

$$\frac{\dot{c}}{c} = \frac{r-\rho}{\sigma_c} \tag{38}$$

$$w = \kappa \frac{c^{\sigma_c}}{(1-\ell)^{\sigma_\ell}} \tag{39}$$

$$p_x(r+\delta_d) - \dot{p}_x = \frac{\beta d^{-\sigma_d} + \left(\frac{d}{H}\right)^{1-\sigma_H} \frac{\gamma}{d}}{c^{-\sigma_c}}. \tag{40}$$

The Effect of Status Concerns and Taxation on the Steady State Allocation. In the parameterized version of the model we are now able to explicitly analyze how status preferences and corrective taxes affect the allocation at the steady state. We start by focussing on status preferences. The strength of status preferences can be measured by the weight of status in utility, γ. We can state the following proposition:

PROPOSITION 1. *At the steady state the following relations hold:*

- *Housing demand increases in status preferences,*

$$\frac{\partial d}{\partial \gamma} > 0\,.$$

- *Hours worked increase in status preferences,*

$$\frac{\partial \ell}{\partial \gamma} > 0\,.$$

- *The capital stock increases in status preferences,*

$$\frac{\partial k}{\partial \gamma} > 0\,.$$

- *The housing-to-capital ratio increases in status preferences,*

$$\frac{\partial (d/k)}{\partial \gamma} > 0\,.$$

Proof. The proof is delegated to the appendix. □

The stronger status preferences are, the larger is the household's housing stock. In order to finance the larger stock of housing, households supply more labor to the labor market and hours worked increase. If the marginal utility of housing would be affected negatively by less leisure time, this would have a dampening effect on the rise of labor supply. However, since status preferences increase housing demand, ceteris paribus, households would still wish to own a larger stock of housing and enjoy less leisure time instead. Consequently, by condition (39) households consume less nondurable consumption. Since at the steady state the capital-to-labor ratio is pinned down by the household's discount factor, the capital stock increases. This perhaps surprising result is a general equilibrium effect. Higher labor supply increases the marginal product of capital. Hence, households have a larger incentive to save also in financial assets and the capital stock increases. Since both types of assets, houses and financial assets, increase a natural question is about the composition of the asset portfolio. At the steady state the housing-to-capital ratio increases implying that the fraction of housing in the total stock of assets increases. This result can also be seen in the light of the secular stagnation debate. Through status concerns the portfolio of households moves towards "non-productive" housing relative to capital used in the production process. Therefore, although increasing the capital stock through the general equilibrium effect, the additional resources gained by supplying more labor predominantly raises the housing stock instead of the capital stock.

We now turn to the question of how introducing housing taxation affects the allocation. Note first that the optimal tax on the transition path is given by

$$\tau^* = -\eta\theta c^{\sigma_c} \tag{41}$$

and at the steady state by

$$\tau^*_{SS} = \frac{\gamma\theta}{\rho+\theta}\frac{c^{\sigma_c}}{H}. \tag{42}$$

Intuitively, the tax undoes part of the additional demand caused by status and the impact of the tax is opposite to that of γ. The following proposition summarizes this finding.

Proposition 2. *At the steady state the following relations hold:*

- *Housing demand decreases in the tax on housing,*

$$\frac{\partial d}{\partial \tau} < 0\,.$$

- *Hours worked decrease in the tax on housing,*

$$\frac{\partial \ell}{\partial \tau} < 0\,.$$

- *The capital stock supply decreases in the tax on housing,*

$$\frac{\partial k}{\partial \tau} < 0 .$$

- *The housing-to-capital ratio decreases in the tax on housing,*

$$\frac{\partial (d/k)}{\partial \tau} < 0 .$$

Proof. The proof is relegated to the appendix. □

5. Quantitative Analysis

For the quantitative analysis we assume that households face quadratic residential adjustment costs, $\psi(x) = \hat{\psi}(x - x^*)^2$ where x^* is the steady state value of residential investment, and that final output producing firms face quadratic capital adjustment costs, $\phi(i/k) = \hat{\phi}(i/k - \delta_k)^2$. This assumption is frequently used in the dynamic macroeconomic literature. The remaining model is implemented in Matlab and impulse responses are obtained by using the Relaxation algorithm (see Trimborn et al., 2008). In contrast to calculating the solution of the linearized dynamic system, the algorithm calculates the exact solution up to a user-specified error. It is hence very useful when utility integrals have to be computed for which an exact solution is needed. We also employ a method to ensure that non-negativity constraints for residential investment and capital investment hold (Trimborn, 2013).

Calibration. We calibrate the model with US data. We set the capital share to 0.38 (as in Strulik and Trimborn, 2012), and the steady state interest rate to 0.06, which implies $\rho = 0.06$. For depreciation of physical capital we take the average rate measured for the U.S. between 1948 and 2001 (Davis and Heathcote, 2005), $\delta_k = 0.058$, and for depreciation of residential houses we take the average between 1948 and 2008 (Davis and Heathcote, 2005; Eerola and Määtänen, 2013), $\delta_d = 0.015$.

The empirical evidence for the size of adjustment costs is mixed, but they are usually estimated to be small (see for example Cooper and Haltiwanger, 2006, and Shapiro, 1986, for different estimates). On the other hand, the DSGE literature estimates much larger adjustment costs (see for example Smets and Wouters, 2007). We dissolve this uncertainty about the size of adjustment cost by setting both adjustment costs parameters equal to one and performing a sensitivity analysis. Our results turn out to be almost independent on the size of adjustment costs.

For the preference parameters related to leisure we assume a Frisch elasticity of one, close to the Micro estimates (see Chetty et al., 2011), and we assume that households supply one quarter of their time endowment on the labor market. This gives $\sigma_\ell = 3$ and $\kappa = 3.49$. We set σ_c and σ_d equal to 2, in accordance with the literature (Chetty, 2006; Ogaki and Reinhart, 1998). The value of β is fixed to match the housing-stock-to-total-asset ratio of households in 2008 of about 0.5 (Iacoviello, 2010 and 2011). Further we calibrate the share parameter of status concerns, γ, and the elasticity of utility with respect to status, σ_H, to match the reported response of households to an increase in their reference stock. Bellet (2017) finds that an increase of 10% in the housing reference stock 1) obliges households to increase their own stock of housing by 1%, and 2) decreases households' satisfaction from housing by 0.43% while leaving the own housing stock unchanged. Following a 10% increase in the steady state reference stock H, the calibrated values of $\gamma = 0.165$ and $\sigma_H = 1.94$ increase the steady state value of housing by 0.1% and decreases sub-utility from housing and housing status by 0.43% when the housing stock remains constant. Finally, we set $\theta = 3.4$ for our benchmark run, in line with the literature on habit formation (see Ravn et al., 2006). The value of θ implies that the reference stock adjusts with a halflife of about 2.5 months. Since our results depend on the speed of habit formation and the size of the preference parameters we conduct an extensive sensitivity analysis with respect to these parameters.

The parameter values of our benchmark calibration are summarized in Table 1.

Table 1. Parameter Values

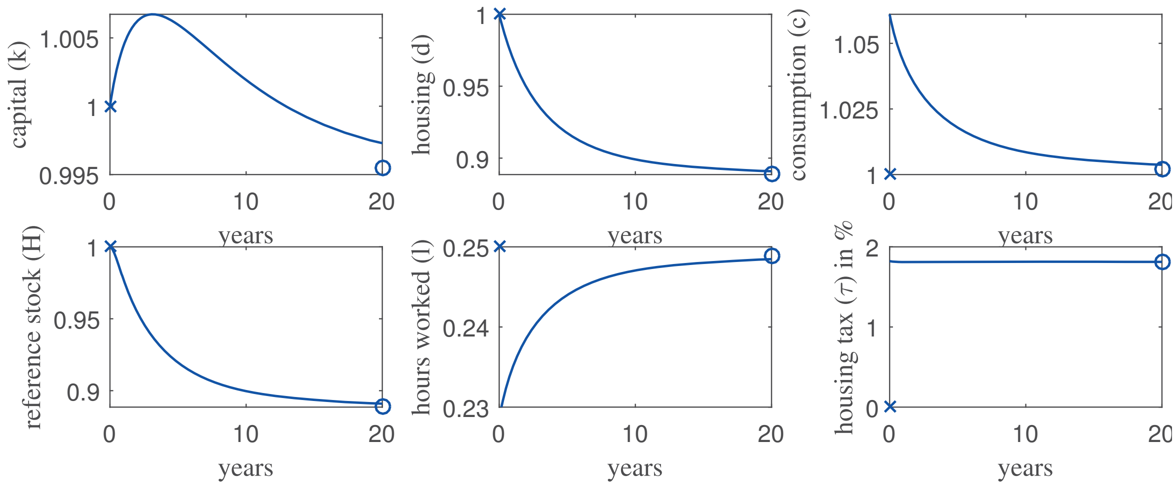
A	α	δ_k	δ_d	r^*	(ρ)	ℓ^*	(κ)	Frisch	(σ_ℓ)	σ_c	(β)	σ_d	(γ)	(σ_H)	$\hat{\psi}$	$\hat{\phi}$	θ
1	0.38	0.058	0.015	0.06	0.06	0.25	3.49	1	3	2	1.06	2	0.175	1.94	1	1	3.4

Notation in parenthesis indicates implied values.

According to our parameter estimates, the socially inefficient fraction of housing demand induced by status is calibrated to be 98% (see Equation (36)). Therefore almost all of the increase in the steady state housing stock triggered by status concerns can be considered socially inefficient.

Results. In the following we present our main numerical application to the model. Suppose the economy rests at the initial steady state as calibrated in the last subsection with no taxes on housing wealth. Then the optimal tax derived above is introduced. Figure 1 illustrates the response of the model variables to the intervention.

Figure 1: Introduction of the Optimal Tax



Response to introduction of the optimal tax on housing wealth. The panel shows impulse responses for capital, k, housing stock, d, consumption, c, housing reference stock, H, hours worked, ℓ, and the optimal housing tax, τ. All values are normalized to 1 at the initial steady state, except for τ. Stars indicate the initial steady state values and circles indicate the final steady state values.

The last panel shows the transition of the optimal tax rate to its steady state level. Note first that the tax rate is remarkably constant over time. It starts at 1.79% right after the intervention and levels off at 1.81% in the steady state. In order to properly interpret the magnitude of the optimal tax, we have to consider that the tax only relates to the value of the housing structures, and not to the value of the land they are build on. Land is not considered in our basic version of the model. In the appendix, however, we show that the inclusion of land and status derived from land do not alter the results regarding the optimal tax rate as land is considered a fixed factor. Therefore status concerns with respect to land do not entail any externality, leaving the optimal tax rate unaffected.

The second panel shows the response of the housing stock to the tax. The housing stock decreases gradually to its new lower steady state level. Quantitatively the drop is quite substantial as the economy's housing demand reduces by more than 10%. Since $d = H$ holds in the steady state, we observe the same drop in the steady state level of reference housing. As we showed in the analytical part above, the tax will reduce the steady state level of labor. Accordingly, nondurable consumption in the new steady state must fall.

The impulse responses give additional insights about the transition process. Since introducing the tax motivates households to lower housing demand, they cut on residential investment (not shown in the panel). In the initial years households have additional resources available, which are used for increasing nondurable consumption. This triggers an intertemporal substitution effect and households also reduce labor supply. The responses of nondurable consumption and hours worked are by magnitude larger during the transition as compared to at the steady state indicating that the effects during the transition process have an important quantitative impact on the economic aggregates and on welfare. The reason that labor supply differs relatively little between the steady state levels lies in the low depreciation rate of the housing stock. Holding an inefficiently high housing stock as at the initial steady state does not require much additional resources and thus leads to comparably few extra hours of work, because only housing depreciation has to be paid to sustain the inefficiently large housing stock. Contrary, if households are motivated to reduce the housing stock considerably, a large amount of resources are freed that can now be used otherwise for nondurable consumption or leisure. Thus introducing the optimal tax has a much larger impact on the transition path as compared to the steady state.

In fact, a household resting at the social optimal steady state enjoys a lower level of instantaneous utility as compared to a household resting at the steady state without taxation. The utility premium of introducing the tax is thus only generated by transitional dynamics. This perhaps puzzling result can best be understood by inspecting a plain vanilla Ramsey model. Since the model exhibits no externalities the market solution is equal to the first best. The resulting steady state capital stock, however, does not yield the maximum steady state consumption (the golden rule consumption level) and thus also not the maximum level of instantaneous utility. Households equipped with a higher capital stock compared to the market solution would find it optimal to consume part of the capital stock such that the transition towards a steady state with lower capital would result in an intertemporal utility gain. In other words, any steady state capital stock higher compared to the market solution is inefficiently high. Transferring this insight to our model implies that households enjoy an intertemporal utility gain by lowering the housing stock to the social optimal level, although instantaneous utility at the social optimal steady state is lower.

Table 2. Sensitivity Analysis

Parameter	τ^*	Δ Welfare	Δ Welfare (constant tax)
benchmark	1.81%	0.291%	0.291%
$\theta = 10.2$	1.84%	0.298%	0.298%
$\theta = 1.13$	1.74%	0.271%	0.271%
$\sigma_c = 2.5$	1.67%	0.245%	0.245%
$\sigma_c = 1.6$	1.96%	0.348%	0.347%
$\sigma_d = 2.5$	1.72%	0.230%	0.230%
$\sigma_d = 1.6$	1.91%	0.361%	0.360%
$\sigma_\ell = 3.75$	1.74%	0.264%	0.264%
$\sigma_\ell = 2.4$	1.88%	0.317%	0.317%
$\hat{\psi} = \hat{\phi} = 0.3$	1.81%	0.291%	0.291%
$\hat{\psi} = \hat{\phi} = 3$	1.81%	0.494%	0.479%
$\sigma_H = 1.91,\ \gamma = 0.268$	2.45%	0.819%	0.808%
$\sigma_H = 1.96,\ \gamma = 0.086$	0.79%	0.065%	0.065%

We next come to the effects which the tax entails for aggregate welfare in the economy. In order to present the welfare gain in countable units, we transform it into nondurable consumption equivalents. We find that the tax results in a welfare gain of 0.29%, measured in consumption equivalents. This means that individuals are better off as if they were consuming 0.29% units more of nondurable consumption in the new steady state. At first glance, this number may not be of considerable size. This impression changes, however, when contrasting our results to comparable outcomes that have been found in the literature. Lucas (1990), for example, examined the welfare gain that is caused by abolishing capital taxation and finds that the resulting gain in consumption equivalents amounts to 1%. Therefore our measure of welfare gain induced by introducing a tax on housing wealth is associated with a gain in consumption equivalents that is about 30% of the gain from eliminating all capital taxes.

Admittedly a state and thus time dependent tax rate is hard to justify when it comes to the practical implementation. As we discussed earlier, however, the tax rate is rather constant over time. We perform our experiment again by implementing the optimal steady state tax rate right from the beginning once and for all. The welfare gain in consumption equivalents still amounts to 0.29% confirming our previous result.

Sensitivity Analysis. In this section we provide a set of robustness checks in order to test sensitivity of our results to assumptions on the model parameters. In particular, we check sensitivity to changes in the adjustment speed θ, the elasticity of utility with respect to nondurable consumption σ_c, to housing σ_d, and to labor σ_ℓ. The results are summarized in Table 2.

The first column shows the values for the parameters, the second column shows the resulting steady state tax rate and the last two columns display the welfare gain in consumption equivalents in the case of implementing the optimal (state dependent) tax rate and the constant steady state tax rate, respectively. The first line reiterates our findings from the benchmark run. The second and third line show results for a three times higher and lower value of θ. Interestingly, the results for the optimal tax and welfare gain are not sensitive to plausible values for the adjustment speed of the reference stock.

The next six lines show results for a 25% increase and decrease in σ_c, σ_d, and σ_ℓ, respectively. For each of the sensitivity checks we recalibrate the model such that the steady state labor supply is still one quarter, the housing-to-total-asset ratio remains 0.5, and the parameter for status preferences are in line with the findings of Bellet (2017). The optimal steady state tax turns out to be remarkably insensitive against changes in the preference parameters.

We also find that implementing the constant steady state tax from the beginning on leads to virtually the same welfare gain as compared to implementing the time varying optimal tax. The reason is that along the transition path the optimal tax barely changes. Hence, the impact on the economy is virtually the same, no matter whether the constant or time-varying tax is implemented.

The second part of the table shows results for different strengths of status concerns. In the penultimate row we raise the the calibration targets for status by 50%. This implies that a 10% increase in the reference stock would make households suffer from a 0.65% drop in utility and they would respond by increasing their stock of housing by 1.5%. For this case our estimated value of σ_H is almost unaffected, while the estimated value for γ also increases by about 50%. Consequently, the optimal steady state tax rises by 50% and the utility gain from introducing the time variable or the constant tax accelerates by almost the factor 3. In the last row we halve the impact of status concerns on household utility and behavior. Again, this has hardly any impact on the estimated value of σ_H, but a strong impact on γ. The value for γ and the resulting optimal steady state tax roughly halves as well. The utility gain approximately declines by the factor 4.

6. Conclusion

We set up a representative agent, neoclassical growth model augmented with a residential housing sector and status concerns for housing. We investigated how status preferences affect household behavior and macroeconomic aggregates such as capital accumulation and labor supply. We found that status preferences for housing increase housing demand. At the same time, households consume less nondurables and supply more labor to be able to afford the larger stock of housing.

We further showed that status preferences cause a negative externality. Households would like to increase their own stock of housing in relation to their peers in order to increase utility from status. However, their peers respond in the same way and also increase their stock of housing, such that everybody's reference stock adjusts and alleviates the utility premium from status. We showed that the main part of housing demand associated with status concerns is inefficient and calculated an optimal tax that internalizes the externality on the transition path and at the steady state.

Our interpretation of the tax is that it accrues to residential structures only, not on the housing costs associated with land. Status concerns with respect to land have no impact on the allocation and hence cause no externality because land is a fixed factor. Knoll et al. (2017) estimate for the US a share of land in total housing value of about one third. Applying this estimate to our optimal tax means that households either pay a 1.8% tax on the residential structure or a $1.8\% * (2/3) \approx 1.2\%$ tax on the total house value.

Due to analytical convenience we confined ourselves to the representative agent approach. However, we are confident that the main mechanism causing the externality would also hold in a heterogeneous agent framework. Households would compare themselves with richer and/or poorer households and would try to improve utility derived from status by increasing their stock of residential housing. However, their peers would respond by also increasing their stock of housing reducing or even nullifying the aspired utility premium from status. Hence, also a heterogeneous agent framework would give rise to corrective taxation on residential housing.

Our paper also contributes to the ongoing debate on subsidies of owner occupied housing and expenditure for affordable housing addressing low income households. For example, a study by Collinson et al. (2015) argues that the US spends more than four times ($195 billion) as much on homeowner subsidies via tax deductions for mortgage interests than for affordable housing for those most in need. By stating that inefficiently high housing demand induced by status should be taxed away by the government, we open up another gateway for challenging those enormous subsidies for home owners.

Finally, our approach could also be extended towards a setting with endogenous tenure decision. The literature on housing taxes has investigated the tax advantage of owner occupied housing relative to rental housing and whether removing the preferential tax treatment of owner occupied housing would cause a welfare gain (see Nakagami and Pereira, 1996; Skinner, 1996; Gervais, 2002; Poterba and Sinai, 2008; Chambers et al., 2009). The main finding is that removing the tax advantage, i.e. taxing owner occupied and rental housing at equal rates, would lead to an efficiency gain and thus to higher economic growth. However, these studies do not consider status preferences for residential housing. If status derived from owner occupied housing is larger as compared to status from rental housing, our results give rise to taxing owner occupied housing even at higher rates compared to rental housing. We leave this question for future research.

Appendix

Proof of Equations (24) and (26). We begin by deriving the Euler equation for consumption (24). The first-order conditions with respect to consumption, capital investments, and capital read

$$\frac{\partial \mathcal{H}}{\partial c} = 0 \quad \Rightarrow \quad u_c(c,d,z,\ell) = \lambda \tag{43}$$

$$\frac{\partial \mathcal{H}}{\partial i} = 0 \quad \Rightarrow \quad \tilde{q} = \lambda\left(1+\phi'\left(\frac{i}{k}\right)\right) \tag{44}$$

$$\frac{\partial \mathcal{H}}{\partial k} = \rho\tilde{q} - \dot{\tilde{q}} \quad \Rightarrow \quad \frac{\dot{\tilde{q}}}{\tilde{q}} = \rho + \delta_k - \frac{\frac{\partial f(k,\ell)}{k} - \phi\left(\frac{i}{k}\right) + \frac{i}{k}\phi'\left(\frac{i}{k}\right)}{1+\phi'\left(\frac{i}{k}\right)}. \tag{45}$$

Log-differentiating Equations (43) and (44) with respect to time provides

$$\frac{\dot{\lambda}}{\lambda} = -\sigma_e\frac{\dot{c}}{c} + \frac{u_d(c,d,z,\ell)\dot{d} + u_z(c,d,z,\ell)\dot{z} + u_l(c,d,z,\ell)\dot{\ell}}{u_c(c,d,z,\ell)} \tag{46}$$

$$\frac{\dot{\lambda}}{\lambda} = \frac{\dot{\tilde{q}}}{\tilde{q}} - \frac{\left(\frac{i}{k}\right)\left(\frac{\dot{i}}{i} - \frac{\dot{k}}{k}\right)\phi''\left(\frac{i}{k}\right)}{1+\phi\left(\frac{i}{k}\right)} \tag{47}$$

where σ_e is defined as above. Combining (46) and (47) with (45) and solving for consumption growth gives

$$\frac{\dot{c}}{c} = \frac{1}{\sigma_e}\left(\frac{\frac{\partial f(k,\ell)}{k} - \phi\left(\frac{i}{k}\right) + \frac{i}{k}\phi'\left(\frac{i}{k}\right) + \left(\frac{i}{k}\right)\left(\frac{\dot{i}}{i} - \frac{\dot{k}}{k}\right)\phi''\left(\frac{i}{k}\right)}{1 + \phi'\left(\frac{i}{k}\right)} - \delta_k - \rho_e\right) \tag{48}$$

where ρ_e is defined as above. Note that the interest rate faced by consumers in the market solution can be solved for from the firm maximization problem. Log-differentiating (19i) with respect to time, using (19j) and solving for r yields

$$r = \frac{\frac{\partial f(k,\ell)}{k} - \phi\left(\frac{i}{k}\right) + \frac{i}{k}\phi'\left(\frac{i}{k}\right) + \left(\frac{i}{k}\right)\left(\frac{\dot{i}}{i} - \frac{\dot{k}}{k}\right)\phi''\left(\frac{i}{k}\right)}{1 + \phi'\left(\frac{i}{k}\right)} - \delta_k. \tag{49}$$

Plugging (49) into (48) provides Equation (24) in the main text.

For deriving Equation (26), note that the first-order conditions with respect to residential investment and housing are given by

$$\frac{\partial \mathcal{H}}{\partial x} = 0 \quad \Rightarrow \quad \mu = \lambda p_x \tag{50}$$

$$\frac{\partial \mathcal{H}}{\partial d} = \rho\mu - \dot{\mu} \quad \Rightarrow \quad \frac{\dot{\mu}}{\mu} = \delta_d + \rho - \frac{u_d(c,d,z,\ell) + u_z(c,d,z,\ell)\frac{\partial z}{\partial d} + \eta\theta}{p_x u_c}. \tag{51}$$

Log-differentiating (50) with respect to time, plugging it into (51) and using (47) gives

$$p_x\left(\frac{\frac{\partial f(k,\ell)}{k} - \phi\left(\frac{i}{k}\right) + \frac{i}{k}\phi'\left(\frac{i}{k}\right) + \left(\frac{i}{k}\right)\left(\frac{\dot{i}}{i} - \frac{\dot{k}}{k}\right)\phi''\left(\frac{i}{k}\right)}{1 + \phi'\left(\frac{i}{k}\right)} - \delta_k + \delta_d\right) - \dot{p}_x = \frac{u_d(c,d,z,\ell) + u_z(c,d,z,\ell)\frac{\partial z}{\partial d} + \eta\theta}{u_c}. \tag{52}$$

Taking into account the expression for the interest rate r in (49) provides Equation (26) in the main text.

Proof of Proposition 1. According to Equation (21), we can express Equation (40) in the steady state as

$$\rho + \delta_d = \frac{\beta d^{-\sigma_d} + \frac{\gamma}{d}}{c^{-\sigma_c}}. \tag{53}$$

Combined with (39), this gives

$$\rho + \delta_d = w\frac{\beta d^{-\sigma_d} + \frac{\gamma}{d}}{\kappa(1-\ell)^{-\sigma_\ell}}. \tag{54}$$

Further, applying $k = a$ ($q = 1$ in the steady state), $r = \rho$ and $\dot{k} = 0$ to the households' budget constraint yields

$$0 = w\ell + \rho k - c - \delta_d d$$

$$\Leftrightarrow \qquad d = \frac{1}{\delta_d}(w\ell + \rho k - c) = \frac{1}{\delta_d}\left(w\ell + \rho\frac{k}{\ell}\ell - \left(\frac{w(1-\ell)^{\sigma_\ell}}{\kappa}\right)^{\frac{1}{\sigma_c}}\right) \equiv d(\ell). \tag{55}$$

Note that the capital-to-labor ratio $\frac{k}{\ell}$ is constant in the steady state. We now have two equations (54) and (55) in two unknowns d and ℓ. Therefore it is possible to calculate the effect that striving for status has on the steady state level of housing. Differentiating (55) with respect to status preference γ we obtain

$$\frac{\partial d(l)}{\partial\gamma} = \frac{1}{\delta_d}\left(w\ell_\gamma + \rho\frac{k}{\ell}\ell_\gamma + \frac{\sigma_\ell}{\sigma_c}\left(\frac{w}{\kappa}\right)^{\frac{1}{\sigma_c}}(1-\ell)^{\frac{\sigma_\ell-\sigma_c}{\sigma_c}}\ell_\gamma\right) \tag{56}$$

which is a positive expression in $\frac{\partial\ell}{\partial\gamma} \equiv \ell_\gamma$. In order to examine how labor supply reacts to status preferences, we merge equations (54) and (55) to get

$$0 = w\frac{\beta d(\ell)^{-\sigma_d} + \frac{\gamma}{d(\ell)}}{\kappa(1-\ell)^{-\sigma_\ell}} - (\rho + \delta_d) \equiv \phi(\ell). \tag{57}$$

By implicitly differentiating (57) we proof point two of the proposition and show that higher preferences for status induce individuals to supply more labor in the steady state,

$$\frac{\partial\ell}{\partial\gamma} = -\frac{\frac{\partial\phi(\ell)}{\partial\gamma}}{\frac{\partial\phi(\ell)}{\partial\ell}} > 0 \tag{58}$$

with

$$\frac{\partial\phi(\ell)}{\partial\gamma} = \frac{w(1-\ell)^{\sigma_\ell}}{d(l)\kappa} > 0 \tag{59}$$

and

$$\frac{\partial\phi(\ell)}{\partial\ell} = \frac{w\left(-\beta\sigma_d d(\ell)^{-\sigma_d-1}\frac{\partial d(\ell)}{\ell} - \frac{\gamma}{d^2}\frac{\partial d(\ell)}{\partial\ell}\right) - \frac{\sigma_\ell}{(1-\ell)}\left(\beta d(\ell)^{-\sigma_d} + \frac{\gamma}{d(l)}\right)}{\kappa(1-\ell)^{-\sigma_\ell}} < 0 \tag{60}$$

where we have used that $\frac{\partial d(\ell)}{\partial\ell} = \frac{1}{\delta_d}\left(w + \rho\frac{k}{l} + \frac{\sigma_\ell}{\sigma_c}\left(\frac{w}{\kappa}\right)^{\frac{1}{\sigma_c}}(1-\ell)^{\frac{\sigma_\ell-\sigma_c}{\sigma_c}}\right) > 0$. Since the capital-labor ratio is constant in the steady state, this implies that the capital stock must be also higher in the setady state which proofs point three of the proposition. Substituting ℓ_γ back into $\frac{d(\ell)}{\partial\gamma}$ in Equation (56) we conclude that status concerns induce individuals to work harder in order to increase the equilibrium stock of housing, i.e.

$$\frac{\partial d}{\partial \gamma} > 0 \tag{61}$$

which proofs point one of the proposition. We can now also determine how the composition of total assets changes due to status concerns, i.e. how $\frac{d}{k}$, or alternatively, $\frac{d/l}{k/l}$ behaves once we introduce status into the model. Knowing that status increases labor supply, we can infer from (39) that consumption in the steady state will decrease accordingly. From the budget constraint in the steady state we see that

$$w + r\frac{k}{l} - \frac{c}{l} - \delta_d \frac{d}{l} = 0. \tag{62}$$

Recall that in the steady state $\frac{k}{l}$ is pinned down by ρ and is thus a constant. From condition (39) we see that c must decrease following an increase in l. Since $\frac{c}{l}$ goes down, $\frac{d}{l}$ has to increase in the steady state. Hence $\frac{d/l}{k/l}$ and thus $\frac{d}{k}$ increases due to status concerns implying that housing accounts for a larger share in total assets. This proofs point 4 of Proposition 1.

Proof of Proposition 2. In a symmetric equilibrium with a housing tax, condition (31) reads

$$\rho + \delta_d = w\frac{\beta d^{-\sigma_d} + \frac{\gamma}{d}}{\kappa(1-\ell)^{-\sigma_\ell}} - \tau. \tag{63}$$

From the modified budget constraint in (30), we can again back out d in the steady state as

$$\begin{aligned} & 0 = w\ell + \rho k - c - \delta_d d - \tau d + T \\ \Leftrightarrow \quad & d = \frac{1}{\delta_d + \tau}(w\ell + \rho k - c + t) = \frac{1}{\delta_d + \tau}\left(w\ell + \rho\frac{k}{\ell}\ell - \left(\frac{w(1-\ell)^{\sigma_\ell}}{\kappa}\right)^{\frac{1}{\sigma_c}} + T\right) \equiv d(\ell). \end{aligned} \tag{64}$$

Differentiating (64) with respect to the tax rate τ we get

$$\frac{\partial d(l)}{\partial \tau} = \frac{1}{\delta_d + \tau}\left[w\ell_\tau + \rho\frac{k}{\ell}\ell_\tau + \frac{\sigma_\ell}{\sigma_c}\left(\frac{w}{\kappa}\right)^{\frac{1}{\sigma_c}}(1-\ell)^{\frac{\sigma_\ell - \sigma_c}{\sigma_c}}\ell_\tau - \frac{1}{\delta_d + \tau}d(\ell)\right). \tag{65}$$

In order to examine how labor supply responds to the housing tax, we combine equations (63) and (64) to obtain

$$0 = w\frac{\beta d(\ell)^{-\sigma_d} + \frac{\gamma}{d(\ell)}}{\kappa(1-\ell)^{-\sigma_\ell}} - \tau - (\rho + \delta_d) \equiv \phi(\ell). \tag{66}$$

By implicitly differentiating (66) we are able show that a higher tax rate will lead to a lower steady state labor supply,

$$\frac{\partial \ell}{\partial \tau} = -\frac{\frac{\partial \phi(\ell)}{\partial \tau}}{\frac{\partial \phi(\ell)}{\partial \ell}} < 0 \tag{67}$$

with

$$\frac{\partial \phi(\ell)}{\partial \tau} = -\tau < 0 \tag{68}$$

and

$$\frac{\partial \phi(\ell)}{\partial \ell} = \frac{w\left(-\beta \sigma_d d(\ell)^{-\sigma_d - 1}\frac{\partial d(\ell)}{\ell} - \frac{\gamma}{d^2}\frac{\partial d(\ell)}{\partial \ell}\right) - \frac{\sigma_\ell}{(1-\ell)}\left(\beta d(\ell)^{-\sigma_d} + \frac{\gamma}{d(l)}\right)}{\kappa(1-\ell)^{-\sigma_\ell}} < 0 \tag{69}$$

where we have used that $\frac{\partial d(\ell)}{\partial \ell} = \frac{1}{\delta_d + \tau}\left(w + \rho\frac{k}{l} + \frac{\sigma_\ell}{\sigma_c}\left(\frac{w}{\kappa}\right)^{\frac{1}{\sigma_c}}(1-\ell)^{\frac{\sigma_\ell - \sigma_c}{\sigma_c}}\right) > 0$. This proofs point two of the proposition and, due to the constant capital-to-labor ratio in the steady state, also point three of the proposition. Substituting ℓ_τ back into $\frac{d(\ell)}{\partial \tau}$ in Equation (65) we see that the housing tax not only decreases labor supply in the steady state but also results in a lower equilibrium stock of housing, i.e.

$$\frac{\partial d}{\partial \tau} < 0. \tag{70}$$

which proofs point one of the proposition. Since the tax income is redistributed to the households, the budget constraint in the steady state reads the same as in (62). With the same argument as above we now conclude that $\frac{d}{k}$ must fall due to the tax which proofs point four of Proposition 2.

Inclusion of Land. We extend our model by including the factor land. The utility function now reads

$$U = u(c, v, z, s, \ell). \tag{71}$$

where $v = dT^{\xi}$ and $s = \frac{T}{R}$. Thus land enters utility in two ways. First, individuals now draw utility from a housing composite v that consists of both the structures and the land they are built on. The parameter ξ measures the importance of land in this composite. Second, individuals draw utility from land status s when comparing their own land to a reference stock R. We add two new flow equations for land T and the reference stock R given by

$$\dot{T} = x_T \tag{72}$$

$$\dot{R} = \psi(\bar{T} - R) \tag{73}$$

where x_T describes investments in land, $\bar{T}$ is the average level of land, and ψ is the adjustment speed of the land reference stock. Accordingly, the budget constraint is modified to

$$\dot{a} = wl + ra - c - p_d x_d - p_T x_T \tag{74}$$

with x_d being the investments in residential housing and p_T the relative price of one unit of land. The Hamiltonian is given by

$$\mathcal{H} = u(c, v, z, s, \ell) + \lambda \dot{a} + \mu \dot{d} + \chi \dot{T} \tag{75}$$

where χ denotes the shadow price of land. Equation (9) changes to

$$r + \delta_d = \frac{T^{\epsilon} u_v(c, v, z, s, \ell) + \frac{1}{H} u_z(c, v, z, s, \ell)}{u_z(c, v, z, s, \ell)}. \tag{76}$$

From the first-order condition $\frac{\partial \mathcal{H}}{\partial x_T} = 0$ we get $\chi = \lambda p_T$. Log-differentiating with respect to time gives $\frac{\dot{\chi}}{\chi} = \frac{\dot{\lambda}}{\lambda} + \frac{\dot{p}_T}{p_T}$. Together with the optimality condition $\frac{\partial \mathcal{H}}{\partial T} = 0$ this yields

$$r p_T - \dot{p}_T = \frac{d \xi T^{\xi - 1} u_v(c, v, z, s, \ell) + \frac{1}{R} u_s(c, v, z, s, \ell)}{u_c(c, v, z, s, \ell)}. \tag{77}$$

The equation implies that the marginal rate of substitution between land and consumption is equal to the relative price of land. The opportunity cost of land in terms of nondurable consumption increases in the forgone consumption goods that could have been purchased instead of investing in land, $p_T r$, and falls following price increases in land, $\dot{p}_T$.

The social planner takes into account that land is actually a fixed factor and can thus not be accumulated. This implies that the reference stock is constant as well. In other words, the social planner sets $\dot{T} = \dot{R} = 0$ and therefore $s = 1$ for all t. The Hamiltonian can now be written as

$$\mathcal{H} = u(c, v, z, 1, \ell) + \lambda \dot{a} + \mu \dot{d} + \eta \dot{H}. \tag{78}$$

The optimal condition for housing demand is then given by

$$r + \delta_d = \frac{T^{\epsilon} u_v(c, v, z, 1, \ell) + \frac{1}{H} u_z(c, v, z, 1, \ell) + \eta\theta}{u_z(c, v, z, 1, \ell)}. \tag{79}$$

Note that although the individual is not internalizing that $s = 1$ for all t, it still must hold for the market solution. Evaluating (76) at $s = 1$ and comparing it to (79) we see that the bias in housing demand through housing status is given by $\eta\theta$. This term coincides with the findings from our benchmark model without land. Hence, the inclusion of land does not entail any additional externality and thus leaves the optimal tax rate unaffected.

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Institute of Statistics and Mathematical Methods in Economics
Vienna University of Technology

Wiedner Hauptstraße 8-10
1040 Vienna
Austria

Phone: +43-1-58801-1053- 1
Fax: +43-1-58801-1053-99
E-mail: wps@econ.tuwien.ac.at