Center for European, Governance and Economic Development Research
cege

Discussion Papers

Number 344 – March 2018

BOOSTING TAXES FOR BOASTING ABOUT HOUSES? STATUS CONCERNS IN THE HOUSING MARKET

Johannes Schünemann
Timo Trimborn

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

ISSN: 1439-2305

Boosting Taxes for Boasting about Houses? Status Concerns in the Housing Market *

Johannes Schünemann† and Timo Trimborn‡

March 2018.

Abstract. There is empirical evidence that households use residential houses as status goods. In particular, people are shown to compare their houses with those at the top of the distribution. In this paper, we introduce a residential housing sector and status concerns for housing into a neoclassical model with heterogeneous agents. We find that status concerns exert a negative externality and calculate a progressive Pigovian tax schedule that corrects for the externality, implying a housing tax for rich households of 4.6%. Implementing the tax schedule is associated with a sizable welfare gain. We also find that when the utilitarian social planner is constrained to housing taxes, Pigovian taxation is not constrained efficient. Further increasing the tax for rich households to 7.9% would maximize welfare in the constrained optimum.

Keywords: Status Concerns; Residential Housing; Pigovian Tax, Constrained Efficiency

JEL: E03; O10; D10; H21; R31

* We would like to thank Franz Hof, Andreas Irmen, Klaus Prettner, Holger Strulik, and seminar participants from the University of Luxembourg for discussion and helpful comments on an earlier version of this paper.

† 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 by their relative socio-economic status is well-established in the economics and psychology literature. Brain image evidence suggests that satisfaction of individuals is driven by both their own income and by their income relative to other people (Fliessbach et al., 2007; Dohmen et al., 2011). There is also evidence from surveys that reported happiness is highly dependent on one's relative income position (Di Tella et al., 2010; Birdal and Ongan, 2016). However, signaling one's own relative position while observing other people's relative position with respect to income or wealth remains a problem. Usually, individuals have little or no direct knowledge about the income and wealth of other people, and can only infer it from observing the behavior of their peers. In this paper, we argue that residential housing serves as a natural measure to signal the relative income and wealth position. In other words, people use residential housing as a positional status good. The reason is that the peers' housing is easily observable – in contrast to other assets like shares or bonds.

Our approach is supported by empirical and survey-experimental evidence that households indeed use residential houses as status goods. Studies suggest that visible goods like cars and houses are used to signal socio-economic status and that these goods are more positional than other less visible consumption goods (Bellet, 2017; Alpizar et al., 2005; Solnick and Hemenway, 2005; Carlsson et al., 2007). In particular, Bellet (2017) reports that U.S. households' housing satisfaction declines when their reference housing stock in the neighborhood increases, holding the own housing stock constant, indicating that housing exerts a negative externality.[1] Interestingly, the study finds that the externality is entirely driven by the top 10% of biggest houses, i.e. people tend to exclusively compare their houses with those at the top of the distribution. This notion is consistent with findings in the psychology literature that individuals weight upward comparisons more heavily than downward comparisons (Boyce et al., 2010; Schor, 1999; Cheung and Lucas, 2016).

In this paper, we introduce housing as a status good into a macroeconomic model and investigate the implications for housing taxation. For this purpose, we extend a neoclassical model

[1]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. 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.

by endogenous labor supply and (owner-occupied) residential housing. Housing services enter household 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. In order to capture the concept of upward comparison, households are assumed to differ in their resource endowments. In particular, we distinguish between rich and poor households where the former are endowed with higher initial wealth, composed of financial and housing capital. The reference housing stock is then a weighted average of the housing stock of the rich and the poor. The model incorporates the empirically interesting case in which the reference stock consists of rich housing only as reported by Bellet (2017).

In our model, the utilitarian social planner would correct for two distortions. The first distortion arises from the unequal distribution of wealth because the social planner would equalize the marginal utility from each of the goods across agents. In other words, if two households were equipped with the same utility function, the social planner would command the same amount of leisure time to both households and redistribute initial wealth such that both households enjoy the same amount of consumption from each good (Saez and Stantcheva, 2016). Apart from this distortion, we show that there exists a negative externality stemming from status concerns. In contrast to the social planner, households do not take into account that increasing their own stock of housing also lifts the reference housing stock, which exerts a negative effect on other households' utility and raises housing demand to inefficiently high levels. For the status externality, we distinguish between a within-group and an in-between-group externality. While the former relates to the external effect that individual behavior has on people in the same socio-economic group, the latter is concerned with the external effect that individual behavior has on people of the other socio-economic group.

We derive Pigovian taxes that internalize the status externality from housing. Since the tax depends on the individual characteristics of households, and in particular on household wealth and permanent income, the internalizing tax differs for both household groups. For the empirically interesting case in which only housing of the rich affects the reference stock (Bellet, 2017), solely rich households are taxed, thereby implying a progressive housing tax scheme. Furthermore, we show that the tax is smaller when only the within-group externality is internalized as compared to the tax which internalizes both status externalities.

In order to quantify the tax and the implied welfare effects, we calibrate a parameterized version of the model to the U.S. To this end, we focus on the case where the housing reference stock consists of only the rich's housing. According to our calibration, the Pigovian tax on rich households internalizing both status externalities amounts to 4.6%. We find that implementing the tax scheme entails an aggregate welfare gain of 0.18%, measured in non-durable consumption equivalents. Interestingly, the implementation of the tax results in a welfare gain for poor households but a welfare loss for the rich. The reason is that the latter are not only taxed for the within-group externality but also charged to correct for the externality that their behavior entails for poor households.

We also investigate the tax schedule that is targeted at internalizing the within-group externality among rich households and hence only partially internalizes the in-between-group externality. It implies a considerably smaller tax for rich households compared to the first tax schedule and, consequently, a substantially lower aggregate welfare gain. Contrary to the first tax schedule, however, the welfare of both household groups increases when it is introduced.

Implementing the Pigovian tax schedules does not naturally result in an aggregate welfare gain because the taxes are introduced in a second-best world. Therefore, we pursue the question of how a utilitarian social planner could improve welfare further, beyond the level of Pigovian taxes, just by implementing housing taxes. For this purpose, we rely on the concept of constrained efficiency (Davila et al., 2012; Nuno and Moll, 2017). The basic idea of constrained efficiency is that the social planner is not allowed to overcome a missing market but is instead constrained to use other policy measures to improve welfare. In our case, we do not allow for redistributive taxation between both groups and restrict the policy measures to constant and linear taxes on the housing stock of the rich. We find that both Pigovian tax schedules are not constraint efficient and calculate a welfare maximizing housing tax for rich households of 7.9% exceeding both Pigovian taxes. Finally, we investigate the welfare maximizing tax rate for a constrained efficient solution in which the planner cannot distinguish between both household groups and is restricted to tax both groups at the same rate. We show that the welfare maximizing tax rate is considerably lower at 0.9%, implying only one-third of the welfare gain as compared to separate taxation.

We acknowledge that, aside from residential housing, durable goods such as cars, bags, or yachts also serve as status goods that can 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]. In our paper, we therefore focus on the role of residential housing as a status good.

The paper is organized as follows. The next subsection provides an overview of the related literature. Section 2 introduces the model with a general utility function. In Section 3, we implement a utilitarian social planner and solve for internalizing tax rates. Section 4 presents the quantitative analysis of introducing Pigovian tax rates with a calibration to the U.S. Section 5 concludes.

1.1. **Related Literature.** In the macroeconomic literature, status concerns have been introduced into neoclassical models in order to investigate the consequences for household behavior and macroeconomic performance (Abel, 1990, 2003; Carroll 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,b, 2011, 2015).[3] However, so far only status concerns with respect to non-durable 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 housing proves to be one of the best visible and thus most natural means to signal income and wealth (as compared to, for example, shares).

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

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

[3]There are also a number of papers which investigate the interaction of externalities from status concerns with those from capital accumulation or 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).

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, our model adds heterogeneity of agents to account for upward comparison which allows for a much richer analysis of housing externalities.

Finally, the present study also relates to the macroeconomic literature on heterogeneous agent as developed by Bewley (1986), İmrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). In this field, most of the literature on taxation is positive, rather than normative, and focuses on labor and capital income taxation (see e.g. Conesa et al., 2009; Benhabib et al., 2011; Heathcote et al., 2017). A few papers discuss the normative implications of this class of models (Davila et al., 2012; Nuno and Moll, 2017; Krueger and Ludwig, 2018), however with a focus an uninsurable risk and not with respect to status concerns.

2. The Model

The economy consists of households, final output producing firms, and construction firms. Households own financial assets and residential houses. We distinguish between rich and poor households in that the former are endowed with a larger initial housing stock and higher initial financial assets than the latter. 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 apply the standard assumption that the accumulation of capital entails 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 when firms adjust the capital stock or investment (see e.g. Cooper and Haltiwanger (2006), for a recent study). We discuss the size of capital adjustment costs in Section 4.2.

2.1. **Households.** The economy is populated by a continuum of households $(0, 1)$ of mass one. Households are heterogeneous with respect to their initial stock of housing and their initial stock

of financial assets. In particular, we distinguish between two types of households. "Rich" and "poor" households, hereafter denoted by the subscript r and p, respectively, are endowed with initial housing stock d_r^0 and d_p^0 as well as initial assets a_r^0 and a_p^0 such that the total wealth of rich households exceeds that of poor households, i.e. $p_x d_r^0 + a_r^0 > p_x d_p^0 + a_p^0$ with p_x denoting the price of residential houses. The share of rich households in the economy is given by the parameter ϑ. We abstract from any strategic interaction between those two groups. Households enjoy utility from non-durable 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 housing with a housing reference stock H of the economy. Specifically, we assume that individuals draw utility from status $d/H \equiv z$. Households maximize

$$\int_0^\infty u^i(c_i, d_i, z_i, \ell_i) e^{-\rho t} dt \tag{1}$$

where ρ denotes the time preference rate and $i = \{r, p\}$. The utility function $u^i(\cdot)$ is assumed to have positive and diminishing marginal returns with respect to each of the inputs c_i, d_i, z_i, and $1-\ell_i$. Households receive labor income $w_i \ell_i$ and capital income $r a_i$. Group-specific wages are captured by $w_i = \psi_i w$ where ψ_i denotes a group-specific productivity factor which is one for poor households and larger than one for rich households, i.e. $\psi_p = 1$, $\psi_r > 1$. Households spend their income for consumption of non-durables and residential investment in owner occupied housing x_i. The budget constraint reads

$$\dot{a}_i = w_i \ell_i + r a_i - c_i - p_x x_i \tag{2}$$

where p_x denotes the price of residential investment in units of non-durable consumption. Durable goods depreciate at rate δ_d. Therefore, the stock of housing evolves according to

$$\dot{d}_i = x_i - \delta_d d_i. \tag{3}$$

The reference stock H adjusts to a weighted average of rich and poor households' housing stocks where the weight of housing of the rich in the reference stock is captured by γ. Therefore, the reference housing stock evolves according to

$$\dot{H} = \theta \left(\left[\gamma \bar{d}_r + (1-\gamma) \bar{d}_p \right] - H \right) \tag{4}$$

where θ represents the adjustment speed of the reference stock and where $\bar{d}_i = \int_0^1 d_i(j)\,\mathrm{d}j$ is the current average stock of housing of type i. 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 $\theta \to \infty$, $H \to [\gamma \bar{d}_r + (1-\gamma)\bar{d}_p]$ for all t. In this setting, the reference stock adjusts infinitely quickly so that people directly compare their stock of housing to the current composite of average housing of the rich and the poor. Therefore, our model is able to capture the case of "keeping up with the Joneses" as well. For both cases, household choices of d_i have no impact on $\bar{d}_i$ and, hence, on H, so that households take the evolution of H exogenous.

Also notice that by simply setting $\gamma = 1$, our model includes the empirically interesting case in which households only compare their houses to those of the rich. In case $\gamma = \vartheta$, the share in the reference stock equals the population share of each household type and the reference stock represents the arithmetic mean of rich and poor households' average housing. In the theoretical part of the paper, we analyze the general case of $0 \leq \gamma \leq 1$, while in the quantitative section (Section 4) we focus on the empirically more relevant case of $\gamma = 1$.

The Hamiltonian of the maximization problem reads

$$\mathcal{H}_i = u^i + \lambda_i(w_i\ell_i + ra_i - c_i - p_x x_i) + \mu_i(x_i - \delta_d d_i), \tag{5}$$

where λ_i and μ_i denote shadow prices of assets and housing, respectively. Note that, for presentational purposes, we suppress the arguments in the utility function from now on. First-order conditions are given by

$$\frac{\partial \mathcal{H}_i}{\partial c_i} = 0 \quad \Rightarrow \quad u^i_{c_i} = \lambda_i \tag{6a}$$

$$\frac{\partial \mathcal{H}_i}{\partial x_i} = 0 \quad \Rightarrow \quad \lambda_i p_x = \mu_i \tag{6b}$$

$$\frac{\partial \mathcal{H}_i}{\partial \ell_i} = 0 \quad \Rightarrow \quad u^i_{\ell_i} = -\lambda_i w_i \tag{6c}$$

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

$$\frac{\partial \mathcal{H}_i}{\partial d_i} = \rho\mu_i - \dot{\mu}_i \quad \Rightarrow \quad u^i_{d_i} + u^i_{z_i}\frac{\partial z_i}{\partial d_i} - \mu_i\delta_d = \rho\mu_i - \dot{\mu}_i \tag{6e}$$

$$\lim_{t\to\infty} e^{-\rho t}\lambda_i a_i = 0 \qquad \lim_{t\to\infty} e^{-\rho t}\mu_i d_i = 0, \tag{6f}$$

where $u^i_{c_i}$ denotes the partial derivative of the utility function of type i with respect to c_i etc. Log-differentiating (6a) with respect to time and using (6d) yields the Euler equation for consumption growth

$$\frac{\dot{c}_i}{c_i} = \frac{r - \rho^e_i}{\sigma^e_i} \tag{7}$$

with

$$\sigma^e_i = -c_i \frac{u^i_{c_i c_i}}{u^i_{c_i}}, \qquad \rho^e_i = \rho - \frac{u^i_{c_i d_i}\dot{d}_i + u^i_{c_i z_i}\dot{z}_i + u^i_{c_i l_i}\dot{\ell}_i}{u^i_{c_i}}$$

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 non-durable consumption c_i and housing d_i is positive ($u^i_{c_i d_i} > 0$). This would mean that the marginal utility of consumption is increasing in the housing stock. In case the housing stock is increasing over time ($\dot{d}_i > 0$), 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_i, z_i, and ℓ_i are additively separable to consumption in the utility function, 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, $\rho^e_i = \rho$ holds.

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

$$w_i = -\frac{u^i_{\ell_i}}{u^i_{c_i}} \equiv MRS^i_{\ell_i c_i}. \tag{8}$$

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

$$\underbrace{\rho - \frac{\dot{\lambda}_i}{\lambda_i}}_{r} - \frac{\dot{p}_x}{p_x} = \frac{u^i_{d_i} + u^i_{z_i}\frac{\partial z_i}{\partial d_i}}{p_x u^i_{c_i}} - \delta_d$$

$$\Leftrightarrow \quad p_x(r + \delta_d) - \dot{p}_x = \frac{u^i_{d_i} + u^i_{z_i}\frac{\partial z_i}{\partial d_i}}{u^i_{c_i}} \equiv MRS^i_{d_i c_i}. \tag{9}$$

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 non-durable consumption. The opportunity costs of one unit of housing in terms of non-durable consumption on the LHS increase 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 $r = MRS^i_{d_i c_i}/p_x + \dot{p_x}/p_x - \delta_d$. 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.

Since status concerns increase the marginal rate of substitution for consumption and housing, they increase housing demand and decrease demand for non-durable consumption, ceteris paribus. If housing, leisure and non-durable consumption are normal goods, higher status concerns also increase labor supply.

2.2. **Construction firms.** There exists a continuum $(0, 1)$ of construction firms producing residential investment goods. We follow the macroeconomic housing literature and assume that these firms convert one unit of final output into one unit of residential investment under perfect competition (Gervais, 2002; Chambers et al., 2009; Eerola and Määttänen, 2013; Strulik and Trimborn, 2018). Therefore, the price of one unit of residential investment is identical to the price of final output, i.e. $p_x = 1$.

2.3. **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 choose investment, i, and labor, L, to maximize

$$\int_0^\infty \left[Af(k, L) - wL - i - k\phi\left(\frac{i}{k}\right)\right] e^{-\int_0^t r(s)ds} dt \tag{10}$$

subject to

$$\dot{k} = i - \delta_k k. \tag{11}$$

First-order conditions are given by

$$w = A\frac{\partial f(k,L)}{\partial L} \tag{12}$$

$$q = 1 + \phi'\left(\frac{i}{k}\right) \tag{13}$$

$$\dot{q} = (r+\delta_k)q - A\frac{\partial f(k,L)}{\partial k} + \phi\left(\frac{i}{k}\right) - \left(\frac{i}{k}\right)\phi'\left(\frac{i}{k}\right) \tag{14}$$

where q denotes the shadow price of capital.

2.4. **General Equilibrium.** Having set up the model in the last section, we will now define the general equilibrium of the economy. We assume symmetry within the strata of the population, i.e. we abstract from differences within the rich as well as the poor household group.

Definition 1. *A general equilibrium consists of time paths for the quantities* $\{d_i, a_i, H, k, L, \ell_i, c_i, x_i, i\}_t^\infty$*, factor prices* $\{r, w\}_t^\infty$*, and shadow price* $\{q\}_t^\infty$ *such that*

(1) $d_i = \bar{d}_i$ *for all* t*,*
(2) *households maximize intertemporal welfare (1),*
(3) *final goods producers maximize profits, i.e. (12), (13), and (14) hold,*
(4) *construction firms maximize profits, i.e.* $p_x = 1$*,*
(5) *the capital market equilibrium condition* $\vartheta a_r + (1-\vartheta)a_p = qk$ *holds,*
(6) *the labor market equilibrium condition* $\vartheta\psi_r\ell_r + (1-\vartheta)\ell_p = L$ *holds, and*
(7) *the goods market equilibrium condition* $y = \vartheta\left(c_r + p_x x_r\right) + (1-\vartheta)\left(c_p + p_x x_p\right) + i + k\phi(i/k)$ *holds.*

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

$$\dot{k} = f(k,L) - \vartheta\left(c_r + x_r\right) - (1-\vartheta)\left(c_p + x_p\right) - \delta_k k - k\phi(i/k). \tag{15}$$

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

$$\dot{k} = f(k,L) - \vartheta\left(c_r + x_r\right) - (1-\vartheta)\left(c_p + x_p\right) - \delta_k k - k\phi(i/k) \tag{16a}$$

$$\dot{d}_i = x_i - \delta_d d_i \tag{16b}$$

$$\dot{H} = \theta\left(\left[\gamma\bar{d}_r + (1-\gamma)\bar{d}_p\right] - H\right) \tag{16c}$$

$$\frac{\dot{c}_i}{c_i} = \frac{r - \rho_i^e}{\sigma_i^e} \tag{16d}$$

$$w_i = -\frac{u^i_{\ell_i}}{u^i_{c_i}} \tag{16e}$$

$$r + \delta_d = \frac{u^i_{d_i} + u^i_{z_i}\frac{\partial z_i}{\partial d_i}}{u^i_{c_i}} \tag{16f}$$

$$w = A\frac{\partial f(k,L)}{\partial L} \tag{16g}$$

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

$$\dot{q} = (r+\delta_k)q - A\frac{\partial f(k,L)}{\partial k} + \phi\left(\frac{i}{k}\right) - \left(\frac{i}{k}\right)\phi'\left(\frac{i}{k}\right) \tag{16i}$$

$$qk = \vartheta a_r + (1-\vartheta)a_p \tag{16j}$$

$$L = \vartheta\psi_r\ell_r + (1-\vartheta)\ell_p \tag{16k}$$

together with the initial conditions $k(0) = k^0$, $a_i(0) = a_i^0$, $d_i(0) = d_i^0$, and $H(0) = H_0$.

2.5. **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 and adjustment costs and marginal adjustment costs are normalized to zero. This implies that in the steady state the aggregate capital-labor ratio is pinned down by the households' discount rate since $\rho = r$ must hold, i.e.

$$\rho = r = Af'(k/L) - \delta_k \tag{17}$$

and hence the wage rate is given as well. Our main equation of interest (9) at the steady state thus reads

$$\rho + \delta_d = \frac{u^i_{d_i} + u^i_{z_i}\frac{\partial z_i}{\partial d_i}}{u^i_{c_i}} \tag{18}$$

where we have used that $p_x = 1$.

3. Negative Externalities, Constrained Efficiency, and Taxation

In this section we analyze whether status concerns exhibit an externality and how the externality can be corrected for by taxing residential houses. We therefore introduce a benevolent

utilitarian social planner with the objective function

$$V = \vartheta \int_0^\infty u^r(c_r, d_r, z_r, \ell_r)e^{-\rho t}dt + (1-\vartheta)\int_0^\infty u^p(c_p, d_p, z_p, \ell_p)e^{-\rho t}dt. \tag{19}$$

In our model, two distortions arise which the social planner would correct for. The first distortion arises from the unequal distribution of wealth because the social planner would equalize the marginal utility from each of the goods across agents. To see this, suppose that both household groups were equipped with the same utility function. Since the utility function is assumed to be concave in every of its arguments, the social planner would command the same amount of leisure time to both households and redistribute initial wealth such that both households enjoy the same amount of consumption from each good (Saez and Stantcheva, 2016). Apart from this distortion, there exists a negative externality stemming from status concerns. In contrast to the social planner, households do not take into account that increasing their own stock of housing also lifts the reference housing stock, which exerts a negative effect on other households' utility and raises housing demand to inefficiently high levels. In other words, 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. However, their peers respond in the same way and also increase their stock of housing such that in equilibrium the utility premium from status is mitigated. For the status externality, we distinguish between within-group and in-between-group externalities. While the former relates to the external effect that individual behavior has on people in the same socio-economic group, the latter is concerned with the external effect that individual behavior has on people of the other socio-economic group.

For calculating the size of both status externalities we now face the following obstacle. If the social planner maximized aggregate welfare as given by equation (19) subject to the resource constraints of the economy, also the distortion from the unequal wealth distribution would be internalized. In order to carve out only the negative external effect of status on household utility, we instead maximize the planner's objective function subject to the household resource constraints and the evolution of the reference stock, $\dot{H}$. In other words, the social planner can be thought of improving *only* on the household decisions about non-durable consumption, housing, and labor supply, taking the factor prices as given. In particular, through this strategy we rule out transfers between households which the planner would have applied to alleviate the

distortion from the unequal wealth distribution. In a second step we then derive Pigovian taxes on the housing stock that exactly internalize the status effect of housing.

The Pigovian taxes we calculate do not necessarily result in an aggregate welfare gain because the taxes are introduced in a second best world. Therefore, a natural question is how the social planner could improve welfare further, beyond the level of Pigovian taxes, just by implementing housing taxes. For this purpose, we rely on the concept of constrained efficiency (Davila et al., 2012; Nuno and Moll, 2017). The basic idea is that the social planner is not allowed to overcome a missing market but instead is constrained to use other policy measures to improve welfare. In our case, we do not allow for redistributive taxation between both groups and restrict the policy measures to constant and linear taxes on housing of the rich household group. Due to the complexity of the problem, we rely on numerical simulation techniques (see Section 4.5) instead of calculating the constrained optimum analytically.[4] Intuitively, Pigovian taxation is not constrained efficient since taxes on housing affect factor prices and therefore allow for further redistribution from rich households (with a low marginal utility) to poor households (with a high marginal utility). We will elaborate further on this channel in the quantitative section.

3.1. **Internalizing Externalities from Housing Status.** We calculate the size of the externality which is caused by status concerns for housing. Contrary to the households, the social planner takes the evolution of the reference stock of housing $\dot{H}$ into account, and that the household's choice of housing d_i equals the average housing stock of households of type i, $\bar{d}_i$. The social planner maximizes (19) subject to $\dot{a}_r$, $\dot{a}_p$, $\dot{d}_r$, $\dot{d}_p$, $\dot{H}$, and with $d_i = \bar{d}_i$. The Hamiltonian is given by

$$\begin{aligned}\mathcal{H} =& \vartheta u^r + (1-\vartheta)u^p + \lambda_r(w_r\ell_r + ra_r - c_r - p_x x_r) + \lambda_p(w_p\ell_p + ra_p - c_p - p_x x_p) \\ &+ \mu_r(x_r - \delta_d d_r) + \mu_p(x_p - \delta_d d_p) + \eta\theta\left([\gamma d_r + (1-\gamma)d_p] - H\right)\end{aligned} \tag{20}$$

where η denotes the shadow price of the reference stock.

Summarizing the first-order conditions as presented above yields

$$\frac{\dot{c}_i}{c_i} = \frac{r - \rho_i^e}{\sigma_i^e} \tag{21}$$

[4]Grossmann et al. (2017) use a similar approach to calculate a welfare maximizing tax regime.

with

$$\sigma_i^e = -c_i \frac{u^i_{c_i c_i}}{u^i_{c_i}}, \qquad \rho_e = \rho - \frac{u^i_{c_i d_i}\dot{d}_i + u^i_{c_i z_i}\dot{z}_i + u^i_{c_i l_i}\dot{\ell}_i}{u^i_{c_i}},$$

$$w_i = -\frac{\tilde{u}^i_{\ell_i}}{\tilde{u}^i_{c_i}} \equiv \widetilde{MRS}^i_{\ell_i c_i} \tag{22}$$

$$p_x(r+\delta_d) - \dot{p}_x = \frac{u^r_{d_r} + u^r_{z_r}\frac{\partial z_r}{\partial d_r} + \frac{\gamma\eta\theta}{\vartheta}}{u^r_{c_r}} \tag{23a}$$

$$p_x(r+\delta_d) - \dot{p}_x = \frac{u^p_{d_p} + u^p_{z_p}\frac{\partial z_p}{\partial d_p} + \frac{(1-\gamma)\eta\theta}{1-\vartheta}}{u^p_{c_p}} \tag{23b}$$

and the flow equation for the shadow price of the reference stock

$$\dot{\eta} = \eta(\rho+\theta) - \vartheta u^r_{z_r}\frac{\partial z_r}{\partial H} - (1-\vartheta)u^p_{z_p}\frac{\partial z_p}{\partial H}. \tag{24}$$

Comparing the optimality conditions to the counterpart of the decentralized economy shows that equations (21) and (22) are the same as in the market solution. However, Equations (23a) and (23b) differ in the numerator to the market solution by $\frac{\gamma\eta\theta}{\vartheta}$ and $\frac{(1-\gamma)\eta\theta}{(1-\vartheta)}$, respectively, implying that an externality arises for the housing demand of rich and poor households. Note that if the reference stock does not adjust to the weighted average stock of housing of the households, i.e. if $\theta = 0$, the market solution and the planner's solution coincide. Also notice that for the empirically interesting case $\gamma = 1$, the reference stock consists of rich households' housing only and the externality exclusively arises for housing demand of the rich. Focusing on the steady state ($\dot{\eta} = 0$), we can derive a simple expression for η given by

$$\eta = \frac{\vartheta u^r_{z_r}\frac{\partial z_r}{\partial H} + (1-\vartheta)u^p_{z_p}\frac{\partial z_p}{\partial H}}{\rho+\theta}. \tag{25}$$

Applying this to the optimality conditions (23a) and (23b) yields

$$\rho + \delta_d = \frac{u^r_{d_r} + u^r_{z_r}\frac{\partial z_r}{\partial d_r} + \frac{\gamma\theta}{\rho+\theta}\left(u^r_{z_r}\frac{\partial z_r}{\partial H} + \frac{1-\vartheta}{\vartheta}u^p_{z_p}\frac{\partial z_p}{\partial H}\right)}{u^r_{c_r}} \tag{26a}$$

$$\rho + \delta_d = \frac{u^p_{d_p} + u^p_{z_p}\frac{\partial z_p}{\partial d_p} + \frac{(1-\gamma)\theta}{\rho+\theta}\left(u^p_{z_p}\frac{\partial z_p}{\partial H} + \frac{\vartheta}{1-\vartheta}u^r_{z_r}\frac{\partial z_r}{\partial H}\right)}{u^p_{c_p}}. \tag{26b}$$

We explain the intuition behind this result by the example of rich households. The explanation holds likewise for poor households. By comparing the social planner's solution (26a) to the market solution (18), we find that the term $\frac{\gamma\theta}{\rho+\theta}\left(u^r_{z_r}\frac{\partial z_r}{\partial H}+\frac{1-\vartheta}{\vartheta}u^p_{z_p}\frac{\partial z_p}{\partial H}\right)$ constitutes the externality in the steady state. The externality thus consists of the negative effect that the increasing reference housing stock has on utility of rich and poor households. In the market solution, rich households fail to take into account that, in case $\gamma > 0$, their higher housing demand triggered by status concerns translates into a higher reference stock which in turn drives down their utility premium from status. Interestingly, also the poor households are affected by this mechanism as they share the same reference stock with the rich. This implies that the increase in the reference stock that is unconsciously caused by a higher housing stock of the rich reduces the utility premium from status for the poor as well. Note that the degree to which the harmful effect for poor households contributes to the total externaility is weighted by the relative share of those households in the economy, $\frac{1-\vartheta}{\vartheta}$.

The size of the external effect is further determined by the ratio $\frac{\theta}{\rho+\theta}$ and is thus increasing in the adjustment speed θ and decreasing in the time preference 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 weighted average housing stock of rich and poor households. Hence, when a 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, thereby driving down the utility premium from status. The household does not take into account that its 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 external effect. Finally, in the limiting case $\theta \to \infty$ and thus $\frac{\theta}{\theta+\rho} \to 1$ so that all of the effect which a higher reference stock has on utility of rich and poor households is inefficient.

Having this in mind it is now straightforward how the household's discount rate ρ affects the size of the external effect. 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 reduces utility from status concerns has less weight for the household (and likewise for the social planner), which decreases the fraction of the reference stock effect that is inefficient.

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

$$\dot{a}_i = w_i \ell_i + r a_i - c_i - p_x x_i - \tau_i d_i + T_i. \tag{27}$$

In line with our modeling of the social planner, the tax income generated from household type i is redistributed to household i by a lump sum transfer T_i, implying zero net transfers across household types. Hence, the government faces two budget constraints according to $\tau_r d_r = T_r$ and $\tau_p d_p = T_p$. We now recalculate the market solution. Equation (9) is then modified to

$$p_x(r + \delta_d) - \dot{p}_x = \frac{u^i_{d_i} + u^i_{z_i} \frac{\partial z_i}{\partial d_i}}{u^i_{c_i}} - \tau_i. \tag{28}$$

The internalizing tax rate can be determined by comparing this optimality condition to its counterpart of the social planner's solution in (23a) and (23b).[5] For the case of $\theta < \infty$ the resulting tax rate is thus given by

$$\tau_r = -\frac{\gamma \eta \theta}{\vartheta u^r_{c_r}} \tag{29a}$$

$$\tau_p = -\frac{(1-\gamma)\eta\theta}{(1-\vartheta) u^p_{c_p}}. \tag{29b}$$

Focusing on the steady state,

$$\tau_{r_{SS}} = -\frac{\gamma\theta}{\rho+\theta} \frac{u^r_{z_r} \frac{\partial z_r}{\partial H} + \frac{1-\vartheta}{\vartheta} u^p_{z_p} \frac{\partial z_p}{\partial H}}{u^r_{c_r}} \tag{30a}$$

$$\tau_{p_{SS}} = -\frac{(1-\gamma)\theta}{\rho+\theta} \frac{u^p_{z_p} \frac{\partial z_p}{\partial H} + \frac{\vartheta}{1-\vartheta} u^r_{z_r} \frac{\partial z_r}{\partial H}}{u^p_{c_p}}. \tag{30b}$$

For the case of $\theta \to \infty$, the internalizing tax is

$$\tau_r = -\gamma \frac{u^r_{z_r} \frac{\partial z_r}{\partial H} + \frac{1-\vartheta}{\vartheta} u^p_{z_p} \frac{\partial z_p}{\partial H}}{u^r_{c_r}} \tag{31a}$$

[5]Grossmann et al. (2013) use a similar procedure to derive the internalizing tax rate.

$$\tau_p = -(1-\gamma)\frac{u^p_{z_p}\frac{\partial z_p}{\partial H} + \frac{\vartheta}{1-\vartheta}u^r_{z_r}\frac{\partial z_r}{\partial H}}{u^p_{c_p}} \tag{31b}$$

at the transition and at the steady state. Since $\frac{\partial z_i}{H} < 0$, in both cases the internalizing tax is positive on the transition path and at the steady state, implying that housing demand in the decentralized economy is too high. The tax coincides with the size of the external effect and thus the comparative statics results regarding the parameters θ and ρ from above apply likewise. Note again that the tax for rich households also corrects for the detrimental effect that their behavior has on the poor and vice versa. In order to further characterize the tax, we will next investigate it for the empirically interesting case in which the housing reference stock consists of rich households' houses only as concluded by Bellet (2017). For this purpose, we assume $\gamma = 1$ such that the reference stock H only depends on houses of the rich d_r. As mentioned above, in this setting status only entails an externality for the behavior of rich households, implying that there is no need for corrective taxes for the poor. We will first derive the tax for the rich internalizing also in-between-group externalities, i.e. externalities that affect both rich and poor households, and second the tax which is targeted at internalizing only within-group externalities among the rich.

Externalities on Rich and Poor Households. The tax imposed on rich households for $\gamma = 1$ internalizing both within-group and in-between-group externalities reads

$$\tau^{**}_r = -\frac{\eta\theta}{\vartheta u^r_{c_r}} \tag{32}$$

and in the steady state

$$\tau^{**}_{r_{SS}} = \frac{\theta}{d_r(\rho+\theta)}\frac{u^r_{z_r} + \frac{1-\vartheta}{\vartheta}\frac{d_p}{d_r}u^p_{z_p}}{u^r_{c_r}} \tag{33}$$

where we have used that $H = d_r$ holds in the steady state. Multiplying the tax rate in equation (33) by d_r gives the total tax payments that the household has to incur. Note that dividing $u^i_{z_i}$ by $u^i_{c_i}$ converts the marginal utility from status into monetary equivalents. Intuitively, at the steady state rich households are charged the marginal gain 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 rich households have to "pay back" all of the monetary marginal gain from status in the economy. The tax also includes

the externality that the behavior of rich households has on the poor. As a consequence, the inefficient part of the monetary marginal gain from status in the economy that is to be taxed away is driven by status concerns of both the rich and the poor. Notice that calculating the aggregate marginal gain from status includes weighting the poor households according to the relative size of their aggregate housing stock $\frac{1-\vartheta}{\vartheta}\frac{d_p}{d_r}$ in the economy.

Within-group-externalities. The tax imposed on rich households as derived in equations (32) and (33) does not coincide with the tax that a planner would choose to accommodate the rich. The reason is that rich households also have to pay for the detrimental effect that their behavior has on the utility of the poor. If the rich had enough power to influence the social planner, they would vote for a lower tax only internalizing the external effect which the behavior of the rich entails for themselves. In this case, the planner only takes status concerns of the rich into account. The tax in this setting can be written as

$$\tau_r^* = -\frac{\tilde{\eta}\theta}{\vartheta u_{c_r}^r} \tag{34}$$

where the differential equation for $\tilde{\eta}$ is given by $\dot{\tilde{\eta}} = \tilde{\eta}(\rho+\theta) - \vartheta u_{z_r}^r \frac{\partial z_r}{\partial H}$. Therefore, the tax in the steady state reads

$$\tau_{r_{SS}}^* = \frac{\theta}{d_r(\rho+\theta)}\frac{u_{z_r}^r}{u_{c_r}^r}. \tag{35}$$

The economic intuition behind this results is similar to the previous case. Again, at the steady state rich households have to pay the marginal gain from status expressed in \$'s weighted by the size of the external effect. The difference is that the rich are only charged for the externality that their behavior entails for themselves and thus $\tau_{r_{SS}}^* < \tau_{r_{SS}}^{**}$. Although this tax will be favored by the rich, the implementation of $\tau_{r_{SS}}^*$ will lead to lower aggregate welfare than the implementation of $\tau_{r_{SS}}^{**}$ since the negative external effect imposed on the poor will only partially be corrected for.

4. Quantitative Analysis

4.1. **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 facilitates the calibration procedure, since we can directly infer the subutility from housing for which we have data.[6] We further assume that the utility functions of both household groups are identical except for two aspects. First, the weight of leisure in utility is group-specific, which allows us to match the same amount of hours worked for rich and poor households at the steady state despite different wealth of both groups. Second, we allow for a group-specific weight of status in utility in order to match the different impact of status concerns on utility as found in the empirical literature.

Individuals maximize the following expression of life-time utility

$$\int_0^\infty \left(\frac{c_i^{1-\sigma_c} - 1}{1-\sigma_c} + \beta_d \frac{d_i^{1-\sigma_d} - 1}{1-\sigma_d} + \beta_{H,i} \frac{1}{1-\sigma_H} \left[\left(\frac{d_i}{H} \right)^{1-\sigma_H} - 1 \right] + \beta_{\ell,i} \frac{(1-\ell_i)^{1-\sigma_\ell} - 1}{1-\sigma_\ell} \right) e^{-\rho t} dt \tag{36}$$

subject to

$$\dot{a}_i = \psi_i w \ell_i + r a_i - c_i - p_x x_i \tag{37}$$

$$\dot{d}_i = x_i - \delta_d d_i \,. \tag{38}$$

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

$$\frac{\dot{c}_i}{c_i} = \frac{r-\rho}{\sigma_c} \tag{39}$$

$$w\psi_i = \beta_{\ell,i} \frac{c_i^{\sigma_c}}{(1-\ell_i)^{\sigma_\ell}} \tag{40}$$

$$p_x(r+\delta_d) - \dot{p}_x = \frac{\beta_d d_i^{-\sigma_d} + \frac{\beta_{H,i}}{d_i} \left(\frac{d_i}{H} \right)^{1-\sigma_H}}{c_i^{-\sigma_c}}. \tag{41}$$

For the formation of the reference stock we rely on the findings of Bellet (2017) and assume that only the housing stock of the rich affects the reference stock. This kind of upward comparison is also consistently found in the literature on social comparison (see e.g. Boyce et al., 2010; Schor, 1999; Cheung and Lucas, 2016). In the context of our model, this implies that $\gamma = 1$ and thus $\dot{H} = \theta(\bar{d}_r - H)$ holds. Therefore, the internalizing taxes on housing wealth of the rich and the

[6]We acknowledge that 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). However, we expect this interaction to be only a second-order effect.

poor are given by

$$\tau_r^{**} = -\frac{\eta\theta}{\vartheta} c_r^{\sigma_c} \tag{42a}$$

$$\tau_p^{**} = 0 \tag{42b}$$

and at the steady state by

$$\tau_{r_{SS}}^{**} = \frac{\theta\beta_{H,r}}{\rho+\theta}\frac{c_r^{\sigma_c}}{H}\left(\left(\frac{d_r}{H}\right)^{1-\sigma_H} + \frac{1-\vartheta}{\vartheta}\left(\frac{d_p}{H}\right)^{1-\sigma_H}\right) \tag{43a}$$

$$\tau_{p_{SS}}^{**} = 0, \tag{43b}$$

respectively. For the supply side, we assume 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 (e.g. Smets and Wouters, 2007). The remaining model is implemented in Matlab and impulse responses are obtained by using the Relaxation algorithm (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 thus very useful when utility integrals have to be computed for which an exact numerical solution is needed. We also employ a method to ensure that non-negativity constraints for residential investment and capital investment hold (Trimborn, 2013).

4.2. **Calibration.** We calibrate the model with U.S. data and fit the model's initial steady state with a zero tax on housing to the U.S. economy. In order to calibrate parameters characterizing both household groups, we mostly rely on disaggregated data from the American Housing Survey (AHS, 2015) and the results from Bellet's (2017) regression analysis. Since the American Housing Survey consists of a comprehensive sample of suburban homeowners, our rich household group in the model can be interpreted as being the suburban homeowners of the top 10% biggest houses of the housing size distribution, and the poor household group being the suburban homeowners of the remaining 90%.

We set the capital share to 0.38 (Strulik and Trimborn, 2012), and the steady state interest rate to 6%, which implies $\rho = 0.06$ (e.g. Barro et al., 1995). For depreciation of physical capital, we take the average rate measured for the U.S. between 1948 and 2001, $\delta_k = 0.058$ (Davis and Heathcote, 2005), and for depreciation of residential houses we take the average between 1948 and 2008, $\delta_d = 0.015$ (Davis and Heathcote, 2005; Eerola and Määttänen, 2013).

The empirical evidence for the size of adjustment costs is mixed, but they are usually estimated to be small (see e.g. Cooper and Haltiwanger (2006) and Shapiro (1986) for different estimates). In contrast, the DSGE literature estimates much larger adjustment costs (Smets and Wouters, 2007). We choose an intermediate value for the adjustment costs and set the value equal to one. Our results turn out to be almost independent of the size of adjustment costs. Furthermore, we set $\theta = 3.4$ in line with the literature on habit formation (Ravn et al., 2006). The value of θ implies that the reference stock adjusts with a halflife of about 2.5 months.

The relative size of the rich household group in total population is given by $\vartheta = 0.1$ according to the decomposition of households in Bellet (2017). For the preference parameters related to leisure we assume a Frisch elasticity of one-half, close to the Micro estimates (Chetty et al., 2011), and we assume that both types of households supply one quarter of their time endowment on the labor market. This gives $\sigma_\ell = 6$, $\beta_{\ell,r} = 0.43$, and $\beta_{\ell,p} = 1.78$. We set σ_c and σ_d equal to 2 for both types of households in accordance with the literature (Chetty, 2006; Ogaki and Reinhart, 1998). The value of β_d is fixed to match the housing-stock-to-total-asset ratio of households in 2008 of about 0.5 (Iacoviello, 2010, 2011), which yields $\beta_d = 1.26$.

In order to match the ratio of rich to poor's total income of 1.47 (AHS, 2015), we calibrate the productivity parameter to $\psi_r = 1.18$. We set the relative initial level of assets to 7.6 in order to match the initial ratio of the rich-to-poor housing stock of 2.4 (AHS, 2015). Therefore, our model replicates the empirical fact that inequality in financial assets is much larger compared to the inequality in labor income and housing (Díaz and Luengo-Prado, 2010).

With respect to the status preference parameters we set $\sigma_H = 2$ and calibrate the share parameter of status such that it replicates the empirical findings of Bellet (2017) for both household groups. He finds that an increase in the average household's reference stock by one percent reduces housing satisfaction by 0.43% while leaving the own housing stock unchanged.[7] He additionally finds that the status effect for the top 10% households is twice as big compared to the disutility experienced from average households. Our household preferences replicate these heterogeneous status effects for $\beta_{H,r} = 0.077$ and $\beta_{H,p} = 0.007$. Thus, while both groups are prone to status concerns, the impact of the reference stock on status is much stronger for rich households, ceteris paribus.

[7]Bellet (2017) reports in his paper that a doubling of the references stock leads to a reduction in housing satisfaction of 0.35 where housing satisfaction is measured on a 1–10 scale. The average housing satisfaction in the sample amounts to 8.2, implying that a decline of 0.35 is on average associated with a reduction of 4.3% in housing satisfaction.

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

TABLE 1. Parameter Values

A. general parameters

A	α	δ_k	δ_d	r^*	$\hat{\phi}$	θ	ψ_r	ϑ
1	0.38	0.058	0.015	0.06	1	3.4	1.18	0.1

B. preference parameters

(ρ)	(β_d)	$(\beta_{H,r})$	$(\beta_{H,p})$	ℓ_r^*	ℓ_p^*	$(\beta_{\ell,r})$	$(\beta_{\ell,p})$	Frisch	(σ_ℓ)	σ_c	σ_d	σ_H
0.06	1.26	0.077	0.007	0.25	0.25	0.43	1.78	0.5	6	2	2	2

Notation in parenthesis indicates implied values.

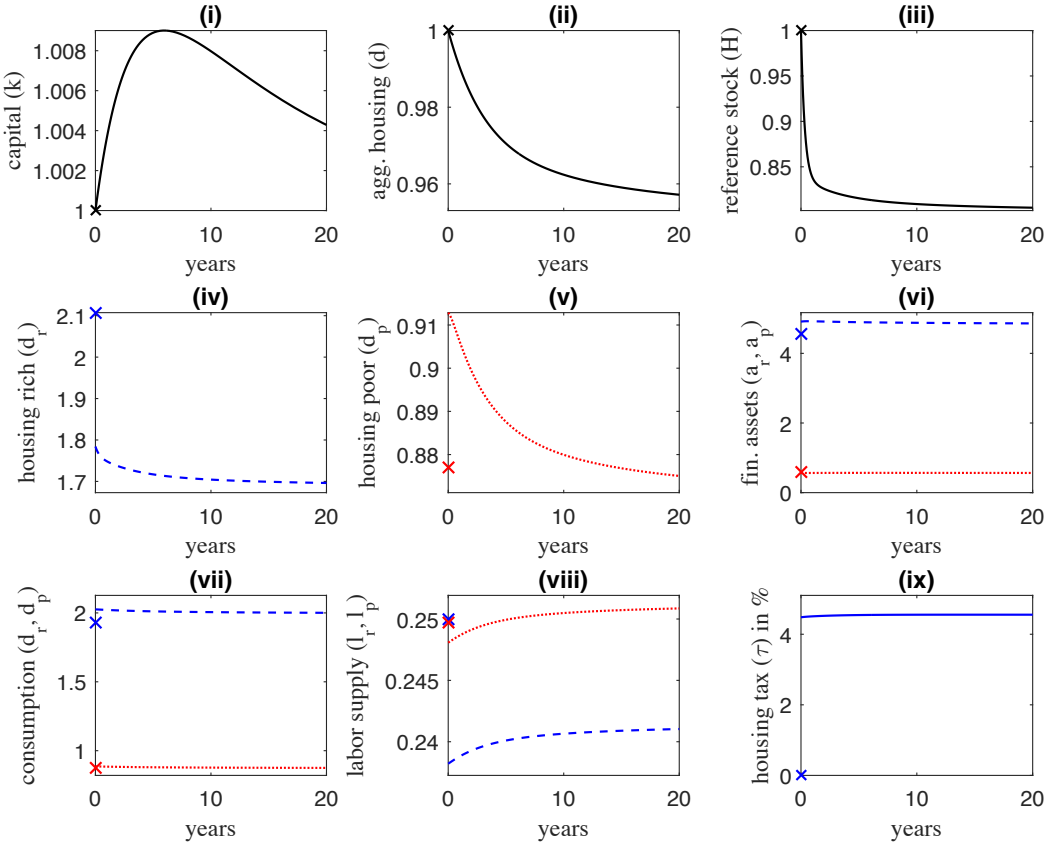
4.3. **Introducing the tax τ_r^{**}.** In the following, we present our main numerical application to the model. Suppose the economy rests at the initial steady state as calibrated in the last subsection with no taxes on housing wealth. Then the tax τ_r^{**} for rich households as derived above is introduced which internalizes both the within-group externality and the in-between-group externality from status. Figure 1 illustrates the response of the model variables to the intervention.

Panel (ix) shows the transition path of the tax to its steady state level. It starts at 4.48% right after the intervention and converges to 4.55% at the steady state. Thus, the tax is remarkably constant over time.

Panel (ii) shows the response of the aggregate 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 aggregate housing demand reduces by more than 4%. During the transition, resources that have previously been used for residential investment are now partially used for capital investment. Therefore, the capital stock increases temporarily and returns towards its steady value in the long-run (panel (i)).

The housing tax has a direct impact on housing demand of rich households. They reduce housing on impact (panel (iv)) and even further during the transition towards the new steady state. At the new steady state, rich households hold almost 20% less housing as compared to the initial steady state. Since $d_r = H$ holds in the steady state, we observe the same drop in the steady state level of reference housing (panel (iii)). For interpreting the response of rich households with respect to labor supply and non-durable consumption, recall that the housing tax is rebated in a lump sum way to rich households, meaning that the tax does not exert a negative income effect. Rich households respond to the resulting substitution effect by increasing

FIGURE 1. Introduction of the Internalizing Tax for both Externalities



Response to introduction of the internalizing tax on housing wealth for both externalities. The panel shows impulse responses for capital, k, the aggregtate housing stock, d, the housing reference stock, H, housing of rich households, d_r, housing of poor households, d_p, financial assets a_r and a_p, consumption c_r and c_p, hours worked, ℓ_r and ℓ_p, and the housing tax, τ_r^{**}. Aggregate values are normalized to 1 at the initial steady state, disaggregated values of d, a, ℓ, and c are normalized by the aggregate respective values of the initial steady state. Black (solid) lines indicate aggregate values, blue (dashed) lines indicate values of rich households, and red (dotted) lines indicate values of poor households. Crosses indicate the initial steady state values.

non-durable consumption and reducing labor supply, since housing, non-durable consumption and leisure are normal goods. This implies that households initially financed the higher housing demand triggered by status concerns by supplying more labor and consuming less non-durable goods.

Poor households are not directly affected by the tax because it only applies to rich households. They are, however, affected by the declining reference stock, which reduces the pressure from status to accumulate a large housing stock. At the new steady state, poor households reduce their housing stock by 0.7% (panel (v)), which is considerably less as compared to rich households. On impact, poor households even demand more housing because the relative price of housing

and financial assets, $1/q$, declines on impact. Contrary to rich households, poor households' non-durable consumption and labor supply are only marginally affected by introducing the tax.

The tax has implications for the distribution of housing. Since rich households reduce their stock of housing by much more compared to poor households, the housing distribution becomes more equal. The rich-to-poor housing size ratio reduces from 2.4 at the initial steady state to almost 1.9 at the new steady state. However, the tax fails to affect the distribution of total assets, $(a_r + d_r)/(a_p + d_p)$, for which the rich-to-poor ratio remains almost constant at 4.5. The reason is that the tax revenues from taxing rich households are redistributed to rich households only. By assumption, inter-group transfers are impossible. Thus, rich households respond to the tax by reducing housing, and increasing their holdings of financial assets at the same time (panel (vi)). This implies that their aggregate asset holdings remain almost unaffected by the tax.

We next come to the effects which the tax entails for welfare. In order to present the welfare effects in countable units, we transform it into non-durable consumption equivalents. For example, a welfare gain for one of the household groups of x% implies that individuals would be indifferent between implementing the policy or changing non-durable consumption by x% forever. Consequently, a gain of x% in aggregate welfare would imply that the social planner is indifferent between implementing the policy measure or raising both household groups' non-durable consumption by x%.

We find that implementing the tax τ_r^{**} entails an aggregate welfare gain of 0.18%, measured in consumption equivalents. 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 results for the welfare gain induced by introducing a tax on housing wealth is associated with a gain in consumption equivalents that is about 18% of the gain from eliminating all capital taxes.

Recall also that the theory of second best implies that introducing τ_r^{**} does not necessarily result in an aggregate welfare gain. In fact, the second distortion (unequal distribution of assets and permanent income across households) which prevails in our model economy might interact with the externalities such that introducing the tax τ_r^{**} results in a welfare loss. We elaborate

more on the interaction of housing taxes with the second distortion below and derive welfare maximizing taxes in the (constrained) optimum.

Another interesting result arises at the disaggregated level. Rich households suffer a welfare loss of -0.88%, whereas poor households gain 0.24%.[8] When internalizing both externalities, the social planner maximizes *aggregate* welfare, not necessarily the welfare of each group. Internalizing the within-group externality with a tax on the rich's houses unambiguously increases welfare for rich households. It raises also welfare for poor households because taxing housing wealth of the rich reduces the rich's stock of housing and hence the reference stock. Poor households gain utility c.p. since they compare their own stock of housing against a smaller reference stock. Raising taxes even higher, beyond the rate which internalizes the within-group externality, further raises the welfare of the poor as the reference stock declines further. However, it may reduce the welfare of the rich even beyond the level of welfare which rich households enjoy at the initial steady state. The social planner weights welfare gains of poor households and welfare losses of rich households employing an utilitarian aggregate welfare function, i.e. he increases the tax such that the marginal welfare loss of rich household equals the marginal welfare gain of poor households, both weighted by the relative size of each group. Our quantitative results show that this would result in a welfare loss for rich households.

4.4. **Introducing the tax τ_r^*.** We showed that introducing the tax τ_r^{**} on housing wealth of the rich results in a welfare loss for the rich household group. Therefore, the tax might be unfeasible to implement, for example for political reasons. We now turn to the implementation of the tax τ_r^*, which is targeted at internalizing only the within-group externality among rich households. Since both types of externalities call for a positive tax, τ_r^* is strictly smaller than τ_r^{**}. The shadow price of the reference stock is now determined by $\tilde{\eta}$ with

$$\dot{\tilde{\eta}} = \tilde{\eta}(\rho + \theta) - \vartheta u_{z_r}(c_r, d_r, z_r, \ell_r)\frac{\partial z_r}{\partial H} \,. \tag{44}$$

Taxes are then given by

$$\tau_r^* = -\frac{\tilde{\eta}\theta}{\vartheta} c_r^{\sigma_c} \tag{45a}$$

$$\tau_p^* = 0 \tag{45b}$$

[8]The numbers do not add up to the aggregate welfare gain, even when considering the unequal size of both groups, due to the concavity of the utility function.

and at the steady state by

$$\tau_r^{*SS} = \frac{\theta\beta_{H,r}}{\rho+\theta}\frac{c_r^{\sigma_c}}{H}\left(\frac{d_r}{H}\right)^{1-\sigma_H} \tag{46a}$$

$$\tau_p^{*SS} = 0. \tag{46b}$$

The tax τ_r^* is equal to 1.46% on impact and increases slightly to 1.47% at the new steady state. Implementing the tax results qualitatively in the same transitional dynamics as after introducing the tax τ_r^{**} which internalizes both externalities. However, housing demand of the rich reduces at the new steady state by only about 8% compared to the initial steady state. Recall that the reduction in housing demand of the rich after implementing τ_r^{**} amounted to 20%. Consequently, the positive response of non-durable consumption and leisure are both smaller than in the previous case.

We find that aggregate welfare increases by 0.088%. The welfare gain splits up into a gain of 0.042% for rich households and a gain of 0.091% for poor households. Again, implementing the tax does not naturally lead to a welfare gain for rich or poor households. Our results thus show that the impact of completely eliminating the within-group externality and partially eliminating the in-between-group externality dominates any welfare-decreasing effect that may result from the interplay with the distortion stemming from the unequal wealth distribution. Table 2 summarizes the welfare results for both types of taxes.

Table 2. Welfare gain

Tax rate	steady state value	rich households	poor households	aggregate gain
τ_r^{**}	4.55%	-0.88%	0.24%	0.18%
τ_r^*	1.47%	0.042%	0.091%	0.088%

τ_r^{**} denotes the tax which internalizes both externalities, whereas τ_r^* denotes the tax which internalizes only the within-group externality of the rich. All welfare changes are expressed in non-durable consumption equivalents. See text for explanation.

4.5. **Constrained Social Optimum: Welfare Maximizing Taxes.** We now turn to the discussion on welfare implications of the constrained optimum. Throughout this subsection we assume that the government's policy options are restricted to constant taxes. On the one hand, this is plausible given that governments usually restrain from introducing time-varying taxes. On the other hand, we have to rely on numerical computation techniques and calculating time- or state-dependent taxes would multiply the numerical complexity. Also note that the

state-dependent taxes we calculated before are hardly changing over time. Therefore, we expect the constrained optimum with constant taxes to be "close" to the constrained optimum with time-varying taxes. Furthermore, in order to compare the results to the Pigovian tax schedule, we assume that poor households are not taxed.

When we derived the internalizing taxes τ_r^{**} and τ_r^{*}, we argued that their implementation may not maximize welfare even when explicit redistribution between households is assumed away. The reason is that housing taxes may interact with the distortion from the unequal distribution of wealth. By affecting the factor prices, housing taxes may implicitly redistribute from the rich to the poor or vice versa. Consequently, the welfare maximizing tax rates deviate from the Pigovian taxes through the factor price channel.

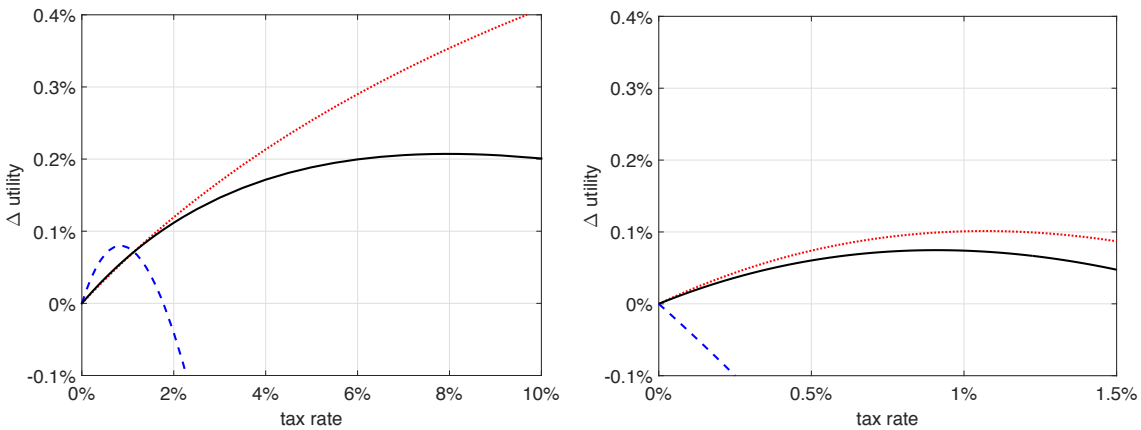
Indeed, the direct effect of the housing tax on the interest rate can be seen by inspecting equation (28). Profit maximization of construction firms implies $p_x = 1$ and thus $\dot{p}_x = 0$ so that the equation reads $r = MRS^i_{d_i c_i} - \delta_d - \tau_i$ in equilibrium. As explained above, this equation can be interpreted as a no-arbitrage condition equating the return on financial assets to that of housing. In case a tax on housing wealth is introduced, investing in housing becomes less attractive, implying that the interest rate on financial assets decreases as well. In other words, households restructure their asset portfolio by divesting houses and investing in financial assets. Higher supply of financial assets reduces the interest rate. As will be shown, the factor price channel exerts a substantial effect on welfare.

The left panel of Figure 2 shows the impact on welfare of introducing a constant tax on housing wealth of the rich. The (black) solid line shows results for aggregate welfare, while the (blue) dashed and the (red) dotted lines represent welfare of the rich and the poor, respectively. Recall that the tax revenues are redistributed to rich households so that explicit redistribution between households is ruled out. Under these conditions, the aggregate welfare maximizing tax in the constrained optimum amounts to $\hat{\tau}_r^{agg} = 7.9\%$. This tax is more than 3 percentage points higher than the tax that is only internalizing housing status externalities, τ_r^{**}. The reason is that through implementing a higher tax, the planner manages to further reduce the interest rate and increase wages during the transition. As a consequence, poor households gain resources relative to rich households which through the concavity of the utility functions leads to a higher aggregate welfare gain (0.21% non-durable consumption equivalents) compared to before (0.18%).

The tax maximizing welfare of the rich is given by $\hat{\tau}_r^r = 0.8\%$. Compared to the Pigovian tax that is favored by the rich if only externalities from housing status are internalized, τ_r^*, this implies a decrease of about 0.7 percentage points. The reduction in the tax again results from the interplay with factor prices. Apparently, it is quantitatively beneficial for rich households if the implemented tax does not internalize all of the external effect induced by housing status when it is overcompensated by shifting factor prices in the favor of the rich.

From a policy perspective, it might be unfeasible to tax only a certain group of the population. To this end, we deviate from the assumption that poor households are not taxed and identify the tax rate that maximizes welfare when both groups are taxed at the same rate. As can be seen in the right panel of Figure 2, the aggregate welfare maximizing tax amounts to $\hat{\hat{\tau}}^{agg} = 0.9\%$, while the welfare maximizing tax of the poor equals $\hat{\hat{\tau}}^{agg} = 1.08\%$. Interestingly, according to our calibration the rich lose from implementing uniform taxes for both households. The reduction of the interest rate in this setting is so pronounced that it balances out any welfare gain from internalizing the housing externalities. Table 3 summarizes the welfare implications of the different taxes.

FIGURE 2. Introduction of a Constant Tax



The left panel shows the welfare change when a constant tax is introduced for rich households while poor households are not taxed. The right panel shows the welfare change when an equal and constant tax is introduced for both household groups. Blue (dashed) lines denote the utility change of rich households, red (dotted) lines denote the utility change of poor households, and black (solid) lines denote the aggregate utility change, all measured in non-durable consumption equivalents.

Table 3. Welfare gain of Constant taxes

Tax rate	rich households	poor households	aggregate gain
$\hat{\tau}_r^{agg}$ =7.9%	-2.55%	0.35%	0.21%
$\hat{\tau}_r^{r}$= 0.8%	0.080%	0.052%	0.053%
$\hat{\hat{\tau}}^{agg}$ =0.9%	-0.40%	0.099%	0.075%
$\hat{\tau}^{p}$= 1.08%	-0.49%	0.10%	0.072%

The upper part shows the welfare effect of introducing a constant tax for the rich household group. Note that poor households are not taxed. $\hat{\tau}_r^{agg}$ denotes the tax rate which maximizes aggregate welfare, and $\hat{\tau}_r^{r}$ denotes the tax rate which maximizes welfare for rich households. The lower part shows the welfare effect of introducing a uniform and constant tax for both household groups. $\hat{\hat{\tau}}_r^{agg}$ denotes the tax rate which maximizes aggregate welfare, and $\hat{\hat{\tau}}_p^{p}$ denotes the tax rate which maximizes welfare of poor households. All welfare changes are expressed in non-durable consumption equivalents. See text for explanation.

5. Conclusion

We set up a heterogeneous-agent neoclassical growth model augmented with a residential housing sector and status concerns for housing. We 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 the reference stock adjusts and reduces the utility premium from status. In particular, we distinguished between externalities which individual behavior entails for people of the same socio-economic group (within-group externalities) and for people of the other socio-economic group (in-between-group externalities). We calculated and quantified a Pigovian tax on housing wealth of rich households that internalizes both types of externalities and found that the implementation of this tax results in a considerable aggregate welfare gain. At the disaggregated level, however, we saw that the aggregate welfare gain was entirely driven by welfare gains of poor households and that rich households suffer from a welfare loss. Therefore, we also determined a Pigovian tax which is targeted at only internalizing within-group externalities among the rich. Implementing this tax leads to a lower aggregate welfare gain compared to the previous case, but results in a welfare gain for both household groups.

We provided further insights for optimal housing taxation by comparing the Pigovian taxes to the constrained social optimum. We found that the welfare maximizing tax in the constrained social optimum is higher than the Pigovian taxes only internalizing housing status externalities.

The reason behind this result is that the higher tax in the constrained optimum partially corrects for the distortion which is triggered by the unequal distribution of wealth.

In order to properly interpret the magnitude of the tax, we have to consider that real world governments also levy distrortionary taxes. In our model, we abstract from taxes on labor, capital and non-durable consumption and tax revenues are rebated in a lump-sum way to households. In reality, when governments do not want to lift transfers after introducing the housing tax, the additional tax revenues could be used to lower distortionary taxes on labor, capital or consumption. Of course, reducing distortionary taxes on factor income or commodities would further increase the welfare gain from housing taxes. This kind of "double dividend" has been discussed in the context on taxes internalizing environmental damage (see e.g. Goulder, 1995; Bovenberg and Goulder, 1996).

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 U.S. 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 of rich households 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 (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.

References

Abel, A. B. (1990). Asset prices under habit formation and catching up with the joneses. *American Economic Review 80*(2), 38–42.

Abel, A. B. (2003). Optimal taxation when consumers have endogenous benchmark levels of consumption. *NBER Working Papers* (10099).

AHS (2015). American housing survey. *U.S. Census Bureau*.

Aiyagari, S. R. (1994). Uninsured idiosyncratic risk and aggregate saving. *The Quarterly Journal of Economics 109*(3), 659–684.

Alonso-Carrera, J., J. Caballé, and X. Raurich (2005). Growth, habit formation, and catching-up with the joneses. *European Economic Review 49*(6), 1665–1691.

Alpizar, F., F. Carlsson, and O. Johansson-Stenman (2005). How much do we care about absolute versus relative income and consumption? *Journal of Economic Behavior & Organization 56*(3), 405 – 421.

Alvarez-Cuadrado, F., G. Monteiro, and S. J. Turnovsky (2004). Habit formation, catching up with the joneses, and economic growth. *Journal of Economic Growth 9*(1), 47–80.

Aronsson, T. and A. Mannberg (2015). Relative consumption of housing: Marginal saving subsidies and income taxes as a second-best policy? *Journal of Economic Behavior & Organization 116*, 439–450.

Barro, R., N. G. Mankiw, and X. Sala-i Martin (1995). Capital mobility in neoclassical models of growth. *American Economic Review 85*(1), 103–15.

Bellet, C. (2017). The paradox of the joneses: Superstar houses and mortgage frenzy in suburban america. *CEP Discussion Paper 1462*.

Benhabib, J., A. Bisin, and S. Zhu (2011). The distribution of wealth and fiscal policy in economies with finitely lived agents. *Econometrica 79*(1), 123–157.

Bewley, T. (1986). Stationary monetary equilibrium with a continuum of independently fluctuating consumers. *Contributions to Mathematical Economics in Honor of Gerard Debreu*, 79–102.

Birdal, M. and H. Ongan (2016). Why do we care about having more than others? Socioeconomic determinants of positional concerns in different domains. *Social Indicator Research 126*(2).

Bovenberg, A. L. and L. H. Goulder (1996). Optimal environmental taxation in the presence of other taxes: General- equilibrium analyses. *The American Economic Review 86*(4), 985–1000.

Boyce, C., G. D A Brown, and S. Moore (2010). Money and happiness: Rank of income, not income, affects life satisfaction. *Psychological Science 21*(4), 471–5.

Carlsson, F., O. Johansson-Stenman, and P. Martinsson (2007). Do you enjoy having more than others? survey evidence of positional goods. *Economica 74*(296), 586–598.

Carroll, C. D., J. Overland, and D. N. Weil (2000). Saving and growth with habit formation. *American Economic Review 90*(3), 341–355.

Chambers, M., C. Garriga, and D. E. Schlagenhauf (2009). Housing policy and the progressivity of income taxation. *Journal of Monetary Economics 56*(8), 1116–1134.

Chetty, R. (2006). A new method of estimating risk aversion. *American Economic Review 96*(5), 1821–1834.

Chetty, R., A. Guren, D. Manoli, and A. Weber (2011). Are micro and macro labor supply elasticities consistent? A review of evidence on the intensive and extensive margins. *American Economic Review, Papers and Proceedings 101*(2).

Cheung, F. and R. E. Lucas (2016). Income inequality is associated with stronger social comparison effects: The effect of relative income on life satisfaction. *ournal of personality and social psychology 110*(2), 332–341.

Collinson, R., I. G. Ellen, and J. Ludwig (2015). Low-income housing policy. Technical report, National Bureau of Economic Research.

Conesa, J. C., S. Kitao, and D. Krueger (2009). Taxing capital? not a bad idea after all! *American Economic Review 99*(1), 25–48.

Cooper, R. and J. Haltiwanger (2006). On the nature of capital adjustment costs. *Review of Economic Studies 73*, 611–633.

Corneo, G. and O. Jeanne (1997). On relative wealth effects and the optimality of growth. *Economics Letters 54*(1), 87–92.

Corneo, G. and O. Jeanne (2001). Status, the distribution of wealth, and growth. *Scandinavian Journal of Economics 103*(2), 283–293.

Davila, J., J. H. Hong, P. Krusell, and J.-V. Ros-Rull (2012). Constrained efficiency in the neoclassical growth model with uninsurable idiosyncratic shocks. *Econometrica 80*(6), 2431–2467.

Davis, M. A. and J. Heathcote (2005). Housing and the business cycle. *International Economic Review 46*(3), 751–784.

Di Tella, R., J. H.-D. New, and R. MacCulloch (2010). Happiness adaptation to income and to status in an individual panel. *Journal of Economic Behavior & Organization 76*(3), 834–852.

Díaz, A. and M. J. Luengo-Prado (2010). The wealth distribution with durable goods*. *International Economic Review 51*(1), 143–170.

Dohmen, T., A. Falk, K. Fliessbach, U. Sunde, and B. Weber (2011). Relative versus absolute income, joy of winning, and gender: Brain imaging evidence. *Journal of Public Economics 95*(3), 279–285.

Eerola, E. and N. Määttänen (2013). The optimal tax treatment of housing capital in the neoclassical growth model. *Journal of Public Economic Theory 15*(6), 912–938.

Fisher, W. and F. Hof (2000). Relative consumption, economic growth, and taxation. *Journal of Economics 72*(3), 241–262.

Fisher, W. and F. Hof (2008). The quest for status and endogenous labor supply: the relative wealth framework. *Journal of Economics 93*(2), 109–144.

Fisher, W. H. and B. J. Heijdra (2009). Keeping up with the ageing joneses. *Journal of Economic Dynamics and Control 33*(1), 53–64.

Fliessbach, K., B. Weber, P. Trautner, T. J. Dohmen, U. Sunde, C. E. Elger, and A. Falk (2007). Social comparison affects reward-related brain activity in the human ventral striatum. *Science 318*.

Futagami, K. and A. Shibata (1998). Keeping one step ahead of the joneses: Status, the distribution of wealth, and long run growth. *Journal of Economic Behavior & Organization 36*(1), 109–126.

García-Peñalosa, C. and S. Turnovsky (2008). Consumption externalities: a representative consumer model when agents are heterogeneous. *Economic Theory 37*(3), 439–467.

Gervais, M. (2002). Housing taxation and capital accumulation. *Journal of Monetary Economics 49*(7), 1461–1489.

Goulder, L. H. (1995). Environmental taxation and the double dividend: A reader's guide. *International Tax and Public Finance 2*(2), 157–183.

Grossmann, V., T. M. Steger, and T. Trimborn (2013). Dynamically optimal R&D subsidization. *Journal of Economic Dynamics and Control 37*, 516–534.

Grossmann, V., T. M. Steger, and T. Trimborn (2016). Quantifying Optimal Growth Policy. *Journal of Public Economic Theory 18*(3), 451–485.

Heathcote, J., K. Storesletten, and G. L. Violante (2017). Optimal tax progressivity: An analytical framework. *The Quarterly Journal of Economics 132*(4), 1693–1754.

Hof, F. X. and K. Prettner (2016). The quest for status and R&D-based growth. Technical report, Vienna University of Technology, Institute for Mathematical Methods in Economics, Research Group Economics (ECON).

Huggett, M. (1993). The risk-free rate in heterogeneous-agent incomplete-insurance economies. *Journal of Economic Dynamics and Control 17*(5), 953 – 969.

Iacoviello, M. (2010). Housing in dsge models: findings and new directions, in Bandt, O. de; Knetsch, T.; Penalosa, J.; Zollino, F. (Eds.). *Housing Markets in Europe: A Macroeconomic Perspective*, Berlin, Heidelberg: Springer–Verlag, 3–16.

Iacoviello, M. (2011). Housing wealth and consumption. *International Encyclopedia of Housing and Home*, Elsevier.

İmrohoroğlu, A. (1989). Cost of business cycles with indivisibilities and liquidity constraints. *Journal of Political Economy 97*(6), 1364–1383.

Krueger, D. and A. Ludwig (2018). Optimal taxes on capital in the olg model with uninsurable idiosyncratic income risk. Working Paper 24335, National Bureau of Economic Research.

Liu, W.-F. and S. J. Turnovsky (2005). Consumption externalities, production externalities, and long-run macroeconomic efficiency. *Journal of Public Economics 89*(5-6), 1097–1129.

Nakagami, Y. and A. M. Pereira (1996). Budgetary and efficiency effects of housing taxation in the united states. *Journal of Urban Economics 39*(1), 68 – 86.

Nakajima, M. (2010). Optimal capital income taxation with housing. Technical report, Working Paper, Federal Reserve Bank of Philadelphia.

Nuno, G. and B. Moll (2017). Social optima in economies with heterogeneous agents. *Review of Economic Dynamics*, forthcoming.

Ogaki, M. and C. M. Reinhart (1998). Measuring intertemporal substitution: The role of durable goods. *Journal of Political Economy 106*(5), 1078–1098.

Poterba, J. M. and T. M. Sinai (2008). Income tax provisions affecting owner-occupied housing: Revenue costs and incentive effects. *NBER Working Papers 14253*.

Ravn, M., S. Schmitt-Grohé, and M. Uribe (2006). Deep habits. *Review of Economic Studies 73*(1), 195–218.

Rossi-Hansberg, E., P.-D. Sarte, and R. Owens (2010). Housing externalities. *Journal of Political Economy 118*(3), 485–535.

Saez, E. and S. Stantcheva (2016). Generalized social marginal welfare weights for optimal tax theory. *American Economic Review 106*(1), 24–45.

Schor, J. B. (1999). *The Overspent American: Why We Want What We Don't Need*. Harper Perennial.

Shapiro, M. (1986). The dynamic demand for capital and labor. *Quarterly Journal of Economics 101*(3), 513–542.

Skinner, J. (1996). The dynamic efficiency cost of not taxing housing. *Journal of Public Economics 59*(3), 397–417.

Smets, F. and R. Wouters (2007). Shocks and frictions in us business cycles: A bayesian DSGE approach. *American Economic Review 97*(3), 586–606.

Solnick, S. J. and D. Hemenway (2005). Are positional concerns stronger in some domains than in others? *American Economic Review 95*(2), 147–151.

Strulik, H. (2015). How status concerns can make us rich and happy. *Economica 82*(s1), 1217–1240.

Strulik, H. and T. Trimborn (2012). Laffer strikes again: Dynamic scoring of capital taxes. *European Economic Review 56*, 1180–1199.

Strulik, H. and T. Trimborn (2018). Natural disasters and macroeconomic performance. *Environmental and Resource Economics*.

Trimborn, T. (2013). Solution of continuous-time dynamic models with inequality constraints. *Economics Letters 119*(3), 299–301.

Trimborn, T., K.-J. Koch, and T. M. Steger (2008). Multidimensional transitional dynamics: A simple numerical procedure. *Macroeconomic Dynamics 12*(3), 301319.

Turnovsky, S. J. and G. Monteiro (2007). Consumption externalities, production externalities, and efficient capital accumulation under time non-separable preferences. *European Economic Review 51*(2), 479–504.

Turnovsky, S. J. and T. Okuyama (1994). Taxes, housing, and capital accumulation in a two-sector growing economy. *Journal of Public Economics 53*(2), 245–267.

Van Long, N. and K. Shimomura (2004). Relative wealth, status-seeking, and catching-up. *Journal of Economic Behavior & Organization 53*(4), 529–542.

Wendner, R. (2010a). Conspicuous consumption and generation replacement in a model of perpetual youth. *Journal of Public Economics 94*(11-12), 1093–1107.

Wendner, R. (2010b). Growth and keeping up with the joneses. *Macroeconomic Dynamics 14*(S2), 176–199.

Wendner, R. (2011). Will the consumption externalities' effects in the ramsey model please stand up? *Economics Letters 111*(3), 210–212.

Wendner, R. (2015). Do positional preferences for wealth and consumption cause inter-temporal distortions? *Graz Economics Papers 2015-03*.