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Optimal fiscal policy in a model with inherited aspirations and habit formation *

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Abstract

In this paper, we analyze optimal fiscal policies in an overlapping generation framework where preferences exhibit aspirations in consumption and environmental quality as well as habit formation. We focus on second best policies when the government needs to finance a given stream of public expenditures by using distortionary taxes. We derive necessary and sufficient conditions under which the competitive equilibrium is characterized by levels of capital and environmental quality that are too small and a level of labor supply that is too large. Our numerical simulations show that an optimal fiscal policy can be used as an effective stabilization device and that when consumption taxes are fixed, the planner implements maintenance and capital subsidies while financing public spending trough income and fixed consumption taxes.

Keywords: Overlapping generations, inherited aspirations, habit formation, environment, fiscal policy, second best.

JEL classification: D62, E62, H21, H23

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1 Introduction

The present paper focuses on the influence of inherited aspirations and habit formation concerning the design of optimal fiscal policies when the government needs to finance public expenditures trough distortionary taxation. The inherited nature of the aspiration process requires some sort of intergenerational linkage and justifies the use of the overlapping generations framework (OLG). While aspirations are inherited from the previous generation and constitute an external benchmark, habit formation is a comparison mechanism that only depends on the private agent. Both elements are used as a frame of reference in order to evaluate utility gains and imply that agents value the perceived increase in the variables that exhibit aspirations or habits and not only their absolute level. In our framework, the short-lived individuals will not internalize the long term impact of their decisions which will give rise to the aspirations of the following generation. Concerning the variables that will be affected by aspirations, we have chosen to focus on consumption and environmental quality. Aspirations in consumption have already been introduced in the Diamond framework (see, for example, de la Croix, 1996; de la Croix and Michel, 1999; Artige et al., 2004; Alonso-Carrera et al., 2007) but none of these works have focused on second best policies when the government needs to finance public expenditures. A notable exception is the work of Aronsson and Johansson-Stenman (2014) in which the authors study the optimal provision of state variable public goods (global climate being the prime example) in a model where people care about relative consumption (including aspirations). We have chosen environmental quality as our second variable since the latter is commonly used as an intergenerational externality where future generations bear the costs imposed by current ones (see, for example, John and Pecchenino, 1994; Ono, 1996; Bovenberg and Heijdra, 1998). Models introducing environmental aspirations are not common and we are only aware of the paper by Schumacher and Zou (2008) where agents experience aspirations in pollution and the authors study the complex dynamics implications of this assumption. Habit formation will in turn affect old age consumption which is standard in two periods overlapping generations models (see, for example, Lahiri and Puhakka, 1998; Wendner, 2002; Alonso-Carrera et al., 2007).

The concepts of aspirations and habit formation are related to the one of relative well being whose importance has been highlighted in several empirical papers such as Clark and Oswald (1996) or Ferrer-i Carbonell (2005) among others. The main conclusion being that utility does not only depend on levels but also on some reference points which are used in welfare evaluations. Concerning more specifically aspirations, Becker (1992) has noted that

individual behavior is affected by aspirations acquired as a child generating the intergenerational transfer of tastes. For example, Waldkirch et al. (2004) estimate that parental preferences explain between 5% and 10% of the preferences of their children after controlling for their respective incomes. Senik (2009) presents evidence showing that an individual's well-being increases if he has done better in life than his parents. This large empirical evidence combined with the important role that endogenous preferences can play concerning environmental issues (see, for example, Brekke and Howarth, 2003; Welsch, 2009) lead us to include consumption and environmental aspirations in our framework. A large number of empirical studies also suggest that the satisfaction derived from present decisions is affected by choices made in the past (de la Croix and Urbain, 1998; Carrasco et al., 2005). This empirical evidence motivates the introduction of habit formation in the current framework.

Our work shares some common features with the literature focusing on the environmental implications of consumption externalities developed by Wendner (2003, 2005), Brekke and Howarth (2003) as well as Howarth (2006) among others. It is also related to models studying at the same time environmental conservation and optimality. Most of these models focus on the planner's problem and on the way to decentralize the first best solution trough an appropriate tax policy while we focus on second best policies. Notable exceptions in line with our approach are the works of Aronsson and Johansson-Stenman (2014) as well as the one of Nakabayashi (2010). The latter focuses on public sector efficiency in an OLG model with environmental quality.

In the present paper we focus on a model where agents live for three periods: during childhood, the agent inherits consumption aspirations from his parents and does not take any decisions. As an adult, the agent works, inherits environmental aspirations and derives utility from consumption net of aspirations and from leisure. In old age, the agent retires and derives utility from consumption net of habits and environmental quality net of aspirations. On the production side, a representative firm produces output by combining capital and labor into a production function with constant returns to scale. Environmental quality is a stock depleted by consumption and that can be regenerated naturally or trough maintenance investment. Taxes which are arbitrarily fixed in the competitive case are used to finance a given stream of public expenditures. Our objective is to study optimal fiscal policy without lump-sum taxation in this model. In order to do so, taxes are chosen in order to maximize the discounted sum of utilities while taking the behavior of private agents as given.

An account of the results is as follows. We derive necessary and sufficient

conditions under which the competitive equilibrium is characterized by levels of capital and environmental quality that are too low and a level of labor supply that is too large. In this case, policies that seek to preserve environmental quality might need to be complemented with capital subsidies. Using a numerical example, we show that our optimal fiscal policy can be used as an efficient stabilization device since the planner's allocation attenuates the endogenous fluctuations observed in the competitive case. We also compute the dynamic path of optimal taxes by fixing consumption taxes in order to be able to compute the rest of the tax rates and obtain both maintenance and investment subsidies while income and fixed consumption taxes are used to finance public spending.
The paper is organized as follows. In section 2 we present the model as well as the competitive equilibrium. Section 3 derives the theoretical results of the paper concerning optimal fiscal policy while section 4 is devoted to the quantitative illustration. Finally, section 5 summarizes the main conclusions.

2 Model

Consider an overlapping generations economy of identical agents where each agent lives for three periods: childhood, young and old age. The size of the population is constant and normalized to one. In the first period of life, the agent does not take any decision and only inherits consumption aspirations from his parents a_t. In young age, the representative agent inherits environmental aspirations H_{t+1}, devotes the time l_t to working and allocates his wage income between consumption c_t, environmental maintenance investment m_t, and savings s_t:

$$(1+\tau_t^c)c_t + (1+\tau_t^m)m_t + s_t = (1-\tau_t^w)w_t l_t,$$

where w_t is the wage rate per unit of time while τ_t^c, τ_t^m and τ_t^w are respectively consumption, maintenance and labor income taxes. The young individual derives utility from leisure $1-l_t$ and from comparing its level of consumption c_t with respect to its aspirations inherited as a child a_t.
In old age, the representative agent retires and consumes the income from his savings:

$$(1+\tau_{t+1}^c)d_{t+1} = [1 + r_{t+1}(1-\tau_{t+1}^r)]s_t,$$

where d_{t+1} is old age consumption while τ_{t+1}^c and τ_{t+1}^r are respectively taxes on old age consumption and savings while r_{t+1} is the net return on savings. Furthermore, the old individual derives utility from comparing its consumption level d_{t+1} with respect to his young age reference c_t and from comparing

the environmental quality level E_{t+1} with respect to its inherited environmental aspiration H_{t+1}.
We consider a lifetime utility function for a generation born in period $t-1$ but that only starts to make decisions in period t. In the following we denominate the latter as generation t and its corresponding utility function is given by

$$U(c_t, a_t, l_t, d_{t+1}, E_{t+1}, H_{t+1}).$$

We assume that the utility function is separable between consumption, labor, and environmental quality and satisfies the following properties: $U_c, U_d, U_E > 0$ while $U_a, U_l, U_H < 0$. Notice that in order to simplify notation, the partial derivates U_d, U_E and U_H are taken with respect to d_{t+1}, E_{t+1} and H_{t+1}. This assumption is justified by the fact that these variables affect the same generation t. Concerning second order derivatives, we assume that the utility function is concave in all arguments. Furthermore $U_{ca}, U_{dc}, U_{EH} > 0$ implying that a rise in aspirations increases the marginal utility of young age consumption and of old age environmental quality while an increase in habits increases the marginal utility of old age consumption. In order to ensure that our utility function is jointly concave in all arguments we also impose

$$\begin{aligned} U_{cc}U_{aa} &\geq U_{ca}^2, \\ U_{dd}U_{cc} &\geq U_{dc}^2, \\ U_{EE}U_{HH} &\geq U_{EH}^2. \end{aligned}$$

As in de la Croix (1996), de la Croix and Michel (1999) or Alonso-Carrera et al. (2007), we consider that aspirations in young age are equivalent to the consumption level of the previous young generation such that children get used to particular consumption standards when living with their parents:

$$a_t = c_{t-1}.$$

In old age, the utility function exhibit habits in consumption as in Alonso-Carrera et al. (2007) as well as aspirations in environmental quality in a way similar to Schumacher and Zou (2008). These authors assume that environmental aspirations are equivalent to the level of environmental quality enjoyed by their parents in old age such that:

$$H_{t+1} = E_t.$$

Output is produced by a representative firm with a production function $F(k_t, n_t)$ using as inputs the current capital stock k_t as well as labor n_t.

The production function exhibits constant returns to scale and is increasing and concave in both arguments. Since we are in a perfectly competitive setup, prices equal marginal productivities and we obtain:

$$\begin{aligned} w_t &= F_n^t, \\ r_t + \delta &= F_k^t, \end{aligned}$$

where $\delta \in (0,1)$ is the depreciation rate of the capital stock and F_i^t represents the marginal productivity of input i at time t. The evolution of environmental quality is given by:

$$E_{t+1} = E_t + b(\overline{E} - E_t) - \kappa_c(c_t + d_t) + \kappa_m m_t,$$

where $\overline{E} > 0$ is the natural level of environmental quality, $b \in (0,1)$ is the natural regeneration rate of the environment, $\kappa_c > 0$ measures the polluting impact of consumption while $\kappa_m > 0$ measures the effectiveness of maintenance investment. As in Ono (1996) or Wendner (2003), we suppose that a given generation takes into account the evolution of environmental quality by internalizing the impact of young age consumption and maintenance investment on the level of environmental quality that she will enjoy when old. There is a government which collects taxes in order to finance a given level of public expenditures G_t:

$$G_t = \tau_t^c(c_t + d_t) + \tau_t^m m_t + \tau_t^w w_t l_t + \tau_t^r r_t s_{t-1}.$$

Market clearing implies that the future capital stock should be equal to the savings of the young generation so that:

$$k_{t+1} = s_t.$$

In order to solve the problem of the representative generation, we will use the intertemporal budget constraint given by:

$$(1+\tau_t^c)c_t + (1+\tau_t^m)m_t - (1-\tau_t^w)w_t l_t + \frac{(1+\tau_{t+1}^c)d_{t+1}}{1+r_{t+1}(1-\tau_{t+1}^r)} = 0.$$

The problem of the representative generation is to maximize lifetime utility subject to the intertemporal budget constraint and the evolution of environmental quality. We obtain the following Lagrangian:

$$\begin{aligned} \mathcal{L} &= U - \lambda_t^1 \left[(1+\tau_t^c)c_t + (1+\tau_t^m)m_t - (1-\tau_t^w)w_t l_t + \frac{(1+\tau_{t+1}^c)d_{t+1}}{1+r_{t+1}(1-\tau_{t+1}^r)} \right] \\ &\quad -\lambda_t^2[E_{t+1} - E_t - b(\overline{E} - E_t) + \kappa_c(c_t + d_t) - \kappa_m m_t], \end{aligned}$$

where λ_t^1 and λ_t^2 are the Lagrange multipliers associated respectively to the intertemporal budget constraint and the law of motion of environmental quality. The first-order conditions (FOC) are given by:

$$\frac{U_c}{U_d} = \frac{[1+r_{t+1}(1-\tau_{t+1}^r)][\kappa_m(1+\tau_t^c)+\kappa_c(1+\tau_t^m)]}{\kappa_m(1+\tau_{t+1}^c)}, \quad (1)$$

$$-\frac{U_c}{U_l} = \frac{\kappa_m(1+\tau_t^c)+\kappa_c(1+\tau_t^m)}{\kappa_m(1-\tau_t^w)w_t}, \quad (2)$$

$$\frac{U_c}{U_E} = \frac{\kappa_m(1+\tau_t^c)+\kappa_c(1+\tau_t^m)}{1+\tau_t^m}. \quad (3)$$

Before defining our competitive equilibrium, we need to derive the feasibility constraint which is given by:

$$c_t + d_t + m_t + k_{t+1} - (1-\delta)k_t + G_t = F(k_t, n_t).$$

Definition 1:
Given a sequence of policies $\{\tau_t^c, \tau_t^m, \tau_t^r, \tau_t^w\}_{t=0}^{\infty}$ and initial conditions $\{k_0, E_0, c_{-1}\}$, a competitive equilibrium of this economy is a sequence of allocations $\{c_t, d_{t+1}, m_t, s_t, l_t, E_{t+1}, G_t\}_{t=0}^{\infty}$, production plans $\{k_t, n_t\}_{t=0}^{\infty}$ and prices $\{r_t, w_t\}_{t=0}^{\infty}$ such that:

(i) the allocations $\{c_t, d_{t+1}, m_t, s_t, l_t, E_{t+1}\}$ solve the consumer's problem given prices $\{r_{t+1}, w_t\}$ and policies $\{\tau_t^c, \tau_{t+1}^c, \tau_t^m, \tau_{t+1}^r, \tau_t^w\}$,

(ii) the production plans $\{k_t, n_t\}$ solve the firm's problem given prices $\{r_t, w_t\}$,

(iii) the government budget constraint holds at each period,

(iv) the labor, capital and goods markets clear,

(v) feasibility is satisfied at each period.

In the competitive equilibrium, government policies are arbitrary and in the following we will study optimal fiscal policies in this economy taking as given the behavior of each generation.

3 Optimal fiscal policy

In this section we will study the optimal fiscal policy in the case where the government has access to some commitment technology preventing it from revising the optimal policy over time. In order to do so, we will follow the

so-called primal approach developed by Lucas and Stokey (1983) as well as Chari and Kehoe (1999). The approach consists in letting the government choose an optimal allocation (instead of the different tax rates) but also to reduce the set from which it can do so. As explained in Erosa and Gervais (2002), using instead the dual approach makes it impossible to analytically characterize the optimal policy. An implementable allocation should satisfy the intertemporal budget constraint of the representative generation as well as the first-order conditions of the competitive equilibrium. Combining these elements we can obtain the so-called implementability constraint which, since we are in an overlapping generations model, is different for each generation. In order to obtain this constraint, we multiply the intertemporal budget constraint of the representative generation by its Lagrange multiplier (λ_t^1). In the present case, we obtain:

$$\lambda_t^1 \left[(1+\tau_t^c)c_t + (1+\tau_t^m)m_t - (1-\tau_t^w)w_t n_t + \frac{(1+\tau_{t+1}^c)d_{t+1}}{1+r_{t+1}(1-\tau_{t+1}^r)} \right] = 0.$$

By using the first-order conditions of the competitive equilibrium in order to substitute for taxes and prices, we obtain our implementability constraint for generation t:

$$U_c c_t + U_E(\kappa_m m_t - \kappa_c c_t) + U_d d_{t+1} + U_n n_t = 0.$$

The objective of the planner is then to maximize the discounted sum of utilities subject to the implementability constraints, the feasibility constraint as well as the law of motion of environmental quality. Concerning the initial old generation, we proceed as in Chari et al. (1996) and adopt the convention that τ_0^r is fixed in order to avoid the possibility of lump sum taxation. We rewrite the problem in the following way: the objective function W^t for generation t includes lifetime utility as well as generation t's implementability constraint:

$$W^t = U + \mu_t[U_c c_t + U_E(\kappa_m m_t - \kappa_c c_t) + U_d d_{t+1} + U_n n_t],$$

where μ_t is the multiplier corresponding to the implementability constraint of generation t. The planner then maximizes the discounted sum ($\zeta > 0$ being the discount factor of the planner) of W^t functions subject to the feasibility constraint and the law of motion of environmental quality:

$$\max \sum_{t=0}^{\infty} \zeta^t W^t,$$

subject to:

$$c_t + d_t + m_t + k_{t+1} - (1-\delta)k_t + G_t - F(k_t, n_t) = 0,$$
$$E_{t+1} - E_t - b(\overline{E} - E_t) + \kappa_c(c_t + d_t) - \kappa_m m_t = 0,$$

given initial conditions $\{k_0, E_0, c_{-1}\}$.
The multipliers of both constraints are given respectively by $-\zeta^t \mu_t^1$ and $\zeta^t \mu_t^2$. We obtain the following first-order conditions:

$$\begin{aligned}
W_c^t + \zeta W_c^{t+1} &= \mu_t^1 - \kappa_c \mu_t^2, && (4)\\
W_d^t &= \zeta \mu_{t+1}^1 - \zeta \kappa_c \mu_{t+1}^2, && (5)\\
W_n^t &= -F_n^t \mu_t^1, && (6)\\
\zeta \mu_{t+1}^1 (1 + F_k^{t+1} - \delta) &= \mu_t^1, && (7)\\
W_m^t &= \mu_t^1 + \kappa_m \mu_t^2, && (8)\\
W_E^t + \zeta W_E^{t+1} &= -\mu_t^2 + \zeta(1-b)\mu_{t+1}^2, && (9)
\end{aligned}$$

where $W_c^t, W_d^t, W_E^t > 0$ while $W_n^t < 0$. Furthermore $W_c^{t+1}, W_E^{t+1} < 0$ since aspirations have a negative impact on the utility of the following generation. The marginal cost of a unit of consumption μ_t^1 must be positive while the marginal cost of a unit of pollution $-\mu_t^2$ is positive as well implying that $W_c^t + \zeta W_c^{t+1} > 0$.
Before proceeding, we establish a relationship between μ_t^2 and μ_{t+1}^2 which will be useful in the following. From expressions (4), (5) and (7), we obtain

$$\begin{aligned}
\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} &= \frac{\mu_t^1 - \kappa_c \mu_t^2}{\zeta \mu_{t+1}^1 - \zeta \kappa_c \mu_{t+1}^2},\\
\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} &= (1 + F_k^{t+1} - \delta)\left[\frac{\mu_t^1 - \kappa_c \mu_t^2}{\mu_t^1 - \zeta \kappa_c \mu_{t+1}^2 (1 + F_k^{t+1} - \delta)}\right]. \quad (10)
\end{aligned}$$

Since the ratio of marginal utilities net of aspirations must be equal to the marginal rate of transformation, it is easy to conclude that

$$\mu_t^2 = \zeta \mu_{t+1}^2 (1 + F_k^{t+1} - \delta). \quad (11)$$

In order to derive the optimal policy, we need to substitute the optimal allocations into the competitive equilibrium conditions. In the present case, we will consider that the planner cannot implement age-dependent taxes implying that he has to set the same consumption taxes to the young and old generations living at the same time. In the following, we will compare the optimal and the competitive allocations in terms of capital, labor and maintenance investment. We then derive the optimal taxes that correspond

to these endogenous variables. We begin by computing the optimal capital tax. By using expressions (10) and (11) from the planner's problem, we obtain:

$$\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} = 1 + F_k^{t+1} - \delta. \tag{12}$$

The left hand side of expression (12) is a modified marginal rate of substitution which takes into account the impact of young and old age consumption on the implementability constraint and internalizes the impact of young age consumption on future aspirations. The latter must then be equal to the optimal gross marginal productivity of capital net of depreciation. We can use expression (1) from the competitive equilibrium to derive

$$\tau_{t+1}^r = \frac{1}{F_k^{t+1} - \delta} \left(\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} - \frac{U_c}{p(.)U_d} \right), \tag{13}$$

where

$$p(\tau_t^c, \tau_t^m, \tau_{t+1}^c) = \frac{(1+\tau_t^c)\kappa_m + (1+\tau_t^m)\kappa_c}{(1+\tau_{t+1}^c)\kappa_m}.$$

We now compute the optimal income tax. By using expressions (4) and (6) from the planner's problem, we obtain:

$$-\frac{W_n^t}{W_c^t + \zeta W_c^{t+1} + \kappa_c \mu_t^2} = F_n^t. \tag{14}$$

Once again, the left hand side of expression (14) is a modified marginal rate of substitution taking into account the impact of labor supply and young age consumption on the implementability constraint and internalizing the impact of young age consumption on future aspirations and environmental quality. It is then equal to the optimal marginal productivity of labor. We use expression (2) from the competitive equilibrium to derive

$$\tau_t^w = 1 - \frac{U_n}{U_c} \left(\frac{W_c^t + \zeta W_c^{t+1} + \kappa_c \mu_t^2}{W_n^t} \right) q(.), \tag{15}$$

where

$$q(\tau_t^c, \tau_t^m) = (1+\tau_t^c) + \frac{\kappa_c(1+\tau_t^m)}{\kappa_m}.$$

Finally, we compute the optimal maintenance investment tax. By using expressions (6), (8) and (9) from the planner's problem, we obtain

$$-\frac{W_m^t + \kappa_m[W_E^t + \zeta W_E^{t+1} - \zeta(1-b)\mu_{t+1}^2]}{W_n^t} = \frac{1}{F_n^t}. \tag{16}$$

The modified marginal rate of substitution on the left hand side of expression (16) takes into account the impact of labor supply and environmental quality on the implementability constraint and internalizes the impact of maintenance investment on future environmental quality. This modified marginal rate of substitution is equal to the inverse of the marginal productivity of labor. We then use expressions (2) and (3) to derive

$$\tau_t^m = \frac{U_E}{U_n}\left[\frac{W_n^t(1-\tau_t^w)}{W_E^t + W_m^t/\kappa_m + \zeta W_E^{t+1} - \zeta(1-b)\mu_{t+1}^2}\right] - 1. \tag{17}$$

Since we use a complete set of instruments, each of our optimal tax rates also depends on a subset of other instruments available to the planner. This is in contrast with some other works that have focused on optimal fiscal policy in an overlapping generations setup. For example, Garriga (2017) only focuses on capital and income taxes which allows him to obtain optimal tax rates that only depend on marginal utilities. In our case, there will be several possible ways to decentralize the optimal outcome depending on the combination of tax rates. Before proceeding, we define some elasticities that we will use in the following propositions:

$$\epsilon_c = -\frac{U_{cc}c_t}{U_c}, \epsilon_d = -\frac{U_{dd}d_{t+1}}{U_d}, \epsilon_n = -\frac{U_{nn}n_t}{U_n}, \epsilon_{cd} = \frac{U_{cd}d_{t+1}}{U_c}, \epsilon_{dc} = \frac{U_{dc}c_t}{U_d}.$$

The first two terms represent the elasticity of marginal utility with respect to young age and old age consumption respectively. The third one is the inverse of the Frisch elasticity of labor supply while the last two terms represent the elasticity of the marginal utility of young age consumption with respect to old age consumption and the elasticity of the marginal utility of old age consumption with respect to young age consumption.
The next proposition focuses on the conditions under which the capital stock is too small in the competitive equilibrium.

Proposition 1: A necessary and sufficient condition for the optimal capital stock to be larger than the competitive one is

$$\mu_t\left(\epsilon_c + \epsilon_{dc} - \epsilon_d - \epsilon_{cd} + \kappa_c\frac{U_E}{U_c}\right) - \frac{\zeta W_c^{t+1}}{U_c} > 0, \tag{18}$$

Proof. The optimal capital stock is larger than the competitive one if and only if

$$\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} < \frac{U_c}{U_d}. \tag{19}$$

From the definition of W^t, we obtain:

$$\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} = \frac{U_c + \mu_t(U_c + U_{cc}c_t - \kappa_c U_E + U_{dc}d_{t+1}) + \zeta W_c^{t+1}}{U_d + \mu_t(U_d + U_{dd}d_{t+1} + U_{cd}c_t)}.$$

Combining both expressions and rearranging, we obtain condition (18).

□

Provided that condition (18) is satisfied, the optimal modified marginal rate of substitution between present and future consumption is smaller than its competitive counterpart and the planner must implement a policy that increases the capital stock. The terms on the left hand side of expression (18) are all positive except for the ones related to the elasticity of marginal utility of old age consumption ϵ_d and the cross elasticity ϵ_{cd}. Large values for both elasticities imply that the optimal value of d_{t+1} should be small. Concerning ϵ_{cd}, a large value of the latter indicates that the planner considers that the representative agent should consume more in young age. This is possible since in the competitive equilibrium, the agent restrains himself from consuming during young age in order to avoid large consumption references when old. When these two effects are sufficiently important, it is possible that the competitive equilibrium exhibits a capital stock that is too large. However, in the current model, the others terms in expression (18) will in general outweigh the impact of ϵ_d and ϵ_{cd}. The need to accumulate more capital in the optimal case comes from several factors. The first ones are the elasticity of marginal utility of young age consumption ϵ_c and the cross elasticity ϵ_{dc} which work in the opposite direction compared to ϵ_d and ϵ_{cd}. Large values of the latter implies that the planner considers that the representative agent should consume less in young age since this will generate larger consumption references when old. The second is the impact of environmental quality on old age utility $\kappa_c U_E$ since less present consumption implies larger levels of environmental quality when old. The last is the impact of present consumption on future aspirations ζW_c^{t+1} which decreases the young age utility of the following generation.

It is useful to notice that without aspirations, habits and environmental quality, condition (18) only depends on ϵ_c and ϵ_d. Provided that the utility function is of the CIES type, $\epsilon_c = \epsilon_d$ and we recover the standard result concerning the non-taxation of capital returns in overlapping generations models where agents live for two periods and only supply labor in the first (Garriga, 2017).

As explained in Atkinson and Sandmo (1980), an intervention on the capital stock under the form of taxes or subsidies should only be used in order to increase efficiency and ensure convergence to the modified golden rule. Erosa

and Gervais (2002) as well as Garriga (2017) show that it is optimal to tax (or subsidize) savings if agents have labor-leisure choices over their entire life. The result does not apply here since we suppose that the agent is retired in the second period of life and our results concerning capital taxation are only driven by aspirations, habits and environmental externalities. The optimal level of capital taxes depends however on the other instruments available to the planner. The next corollary indicates the influence of consumption and maintenance taxes on the optimal capital tax when the competitive equilibrium exhibits a capital stock that is too small.

Corollary 1: Provided that

$$\frac{W_c^t + \zeta W_c^{t+1}}{W_d^t} < \frac{U_c}{U_d}, \tag{20}$$

$\exists p = \overline{p} > 1$ for which $\tau_{t+1}^r = 0$. In addition, if $p > \overline{p}$, $\tau_{t+1}^r > 0$ while if $p < \overline{p}$, $\tau_{t+1}^r < 0$.

Proof. From expression (13), it is straightforward to notice that if inequality (20) is satisfied, there exists a value of $p = \overline{p} > 1$ for which $\tau_{t+1}^r = 0$. Since $\partial \tau_{t+1}^r / \partial p > 0$, the rest of the corollary follows. □

Corollary 1 implies that the implementation of environmental policies under the form of increasing pollution taxes ($\tau_{t+1}^c > \tau_t^c$) and maintenance subsidies ($\tau_t^m < 0$) increases the probability that $p < \overline{p}$ and consequently $\tau_{t+1}^r < 0$. In this case, the planner would need to implement investment subsidies in order to ensure an optimal accumulation of capital along the dynamic path. Intuitively, without an additional incentive to save, the combination of consumption aspirations and maintenance subsidies will depress capital accumulation and affect negatively the welfare of future generations. The next proposition focuses on the conditions under which the representative agent supplies too much labor in the competitive case.

Proposition 2: A necessary and sufficient condition for the optimal labor supply to be smaller than the competitive one is

$$\mu_t \left(\epsilon_c - \epsilon_{cd} - \epsilon_n + \kappa_c \frac{U_E}{U_c} \right) - \left(\frac{\zeta W_c^{t+1} + \kappa_c \mu_t^2}{U_c} \right) > 0, \tag{21}$$

Proof. The optimal labor supply is smaller than the competitive one if and only if

$$-\frac{U_n}{U_c} < -\frac{W_n^t}{W_c^t + \zeta W_c^{t+1} + \kappa_c \mu_t^2}. \tag{22}$$

From the definition of W^t, we obtain:

$$\frac{W_n^t}{W_c^t + \zeta W_c^{t+1} + \kappa_c \mu_t^2} = \frac{U_n + \mu_t(U_n + U_{nn} n_t)}{U_c + \mu_t(U_c + U_{cc} c_t - \kappa_c U_E + U_{dc} d_{t+1}) + \zeta W_c^{t+1} + \kappa_c \mu_t^2}.$$

Combining both expressions and rearranging, we obtain condition (21). □

The result of proposition 2 derives from condition (21) under which the optimal modified marginal rate of substitution between labor supply and young age consumption is larger than its equilibrium counterpart and the planner needs to reduce the labor supply in some way. There are again several factors that justify this kind of intervention. First, a large elasticity of marginal utility of young age consumption ϵ_c implies a small optimal level of c_t and thus a reduction in the labor supply. Second, the larger the impact of young age consumption on future aspirations ζW_c^{t+1}, the larger the incentive to reduce the quantity of labor. Third, the impact of young age consumption on future environmental quality $\kappa_c U_E$ also justifies a reduction of labor supply. On the contrary, there are also some elements that go against the incentive to reduce the latter. These are a large elasticity of the marginal disutility of labor ϵ_n as well as a large cross elasticity ϵ_{cd}. The first element implies that the optimal labor supply should be sufficiently large while the second one implies that the representative agent should consume more in young age. Both elasticities tend to decrease the need to reduce the labor supply. The optimal income tax will however depend on the value of the tax rates applied to present consumption and maintenance investment. The next corollary indicates their influence on the optimal income tax when the competitive labor supply is too large.

Corollary 2: Provided that

$$-\frac{U_n}{U_c} < -\frac{W_n^t}{W_c^t + \zeta W_c^{t+1} + \kappa_c \mu_t^2}, \tag{23}$$

$\exists q = \overline{q} > 1$, for which $\tau_t^w = 0$. In addition, if $q > \overline{q}$, $\tau_t^w < 0$ while if $q < \overline{q}$, $\tau_t^w > 0$.

Proof. From expression (15), it is straightforward to notice that if inequality (23) is satisfied, there exists a value of $q = \overline{q} > 1$ for which $\tau_t^w = 0$. Since $\partial \tau_t^w / \partial q < 0$, the rest of the corollary follows. □

Corollary 2 implies that when the government needs to reduce the labor supply, he can do so by taxing either income or consumption goods (maintenance investment can be interpreted as a specific consumption good). The

function $q(.)$ takes larger values when consumption and maintenance investment taxes are large. According to the last corollary, the latter is associated to lower income taxes. The result is in line with the one of Atkinson and Stiglitz (1976) showing that no indirect taxation is required when income can be directly taxed. The only difference in our framework is the presence of a second consumption good under the form of maintenance investment.
The next proposition focuses finally on the condition under which the competitive equilibrium generates a level of environmental quality that is too small.

Proposition 3: A necessary and sufficient condition for the optimal environmental quality stock to be larger than the competitive one is

$$\begin{aligned} &\frac{1}{U_E}\left[W_m^t/\kappa_m + \zeta W_E^{t+1} - \zeta(1-b)\mu_{t+1}^2\right] \\ &+\mu_t\left[\frac{U_{EE}}{U_E}(\kappa_m m_t - \kappa_c c_t) - 1 + \epsilon_n\right] > 0. \end{aligned} \tag{24}$$

Proof. The optimal environmental quality stock is larger than the competitive one if and only if

$$-\frac{U_E}{U_n} < -\frac{W_E^t + W_m^t/\kappa_m + \zeta W_E^{t+1} - \zeta(1-b)\mu_{t+1}^2}{W_n^t}.$$

Using the definition of W^t, we obtain

$$\begin{aligned} -W_n^t &= -U_n - \mu_t(U_n + U_{nn}n_t), \\ W_E^t &= U_E + \mu_t U_{EE}(\kappa_m m_t - \kappa_c c_t). \end{aligned}$$

Combining the latter expressions and rearranging we obtain condition (24). □

Provided that condition (24) is satisfied, the optimal modified marginal rate of substitution between environmental quality and labor is larger than in the competitive case and the planner must implement a policy that increases environmental quality. While such an outcome is not intuitively surprising, they are elements in expression (24) that reduce the need to accumulate a larger stock of environmental quality in the optimal case. These are mainly driven by the negative impact of environmental aspirations on future generations ζW_E^{t+1} and the possibility that the latter will over-invest in maintenance investment in order to avoid large losses of utility when old. However, in most cases, this impact is not large enough to avoid the conclusion that the competitive case exhibits a too small stock of environmental quality.

Corollary 3: Provided that

$$-\frac{U_E}{U_n} < -\frac{W_E^t + W_m^t/\kappa_m + \zeta W_E^{t+1} - \zeta(1-b)\mu_{t+1}^2}{W_n^t}, \tag{25}$$

$\exists \tau_t^w = \overline{\tau}_t^w < 0$, for which $\tau_t^m = 0$. In addition, if $\tau_t^w > \overline{\tau}_t^w$, $\tau_t^m < 0$ while if $\tau_t^w < \overline{\tau}_t^w$, $\tau_t^m > 0$.

Proof. From expression (17), it is straightforward to notice that if inequality (25) is satisfied, there exists a value of $\tau_t^w = \overline{\tau}_t^w < 0$ for which $\tau_t^m = 0$. Since $\partial \tau_t^m / \partial \tau_t^w < 0$, the rest of the corollary follows. □

The last corollary shows that if the government relies on income taxes in order to finance public expenditures, this will generate additional spending in terms of maintenance investment subsidies. This is due to the need to decentralize the optimal allocation which is characterized by a larger environmental quality stock compared to the competitive case.
Having characterized the behavior of the tax rates in our economy, we will now proceed with a quantitative illustration of our model.

4 A quantitative illustration

In this section, we numerically simulate the model with the following two objectives: the first consists in showing that for realistic parameter values, the competitive equilibrium generates endogenous fluctuations and that an adequate optimal fiscal policy can be used as an effective stabilization device. The second objective consists in computing numerically the tax rates that decentralize the optimal allocation as a competitive outcome. In order to realize the second task, we will use the marginal utilities from the optimal allocation and substitute them into the competitive one in order to obtain the tax rates. However, as can be seen from the competitive equilibrium, we have three first-order conditions and the government budget constraint while we need to compute the values of five tax rates $(\tau_t^c, \tau_{t+1}^c, \tau_{t+1}^r, \tau_t^w, \tau_t^m)$. We then choose to fix $\tau_t^c = \tau_{t+1}^c = \tau^c$ at a given constant and to compute optimally the other tax rates by using expressions (13), (15) and (17).

4.1 Parametrization

We will consider that one period of the model is equivalent to 30 years which is a standard assumption in this class of models. We use the following particular

utility function for our simulations:

$$U = \theta \ln(c_t - \rho_c a_t) - \epsilon \frac{l^{1+\sigma}}{1+\sigma} + \beta\theta \ln(d_{t+1} - \rho_d c_t) + \beta\eta \ln(E_{t+1} - \rho_e E_t).$$

Appendix A presents the planner's problem with this specific utility function and computes the marginal utilities that we have used in the numerical example.

This particular formulation satisfies our separability and concavity assumptions but we still need to ensure that the indifference curve between young and old age consumption is downward sloping which requires

$$\frac{d_{t+1}}{(1+\beta)c_t - \beta\rho_c a_t} > \rho_d,$$

implying that the parameter governing the intensity of habit formation ρ_d cannot be too large.

We choose a logarithmic formulation for consumption and environmental quality as well as a constant Frisch elasticity formulation concerning labor supply. Due to the presence of aspirations and habits, the implementability constraints are not independent of consumption and environmental quality despite our logarithmic formulation. The reason for not adopting a similar logarithmic formulation concerning labor supply is that this would imply that the implementability constraints are independent of the latter.

The parameters $\rho_c, \rho_e, \rho_d \in (0,1)$ govern the intensity of the comparison effects while $\beta \in (0,1)$ is the representative agent's discount factor.

The relative preference for consumption θ is normalized to one implying a relative preference for leisure $\epsilon = 2$ in accordance with the literature. We consider a quarterly psychological discount factor of 0.99 implying that $\beta = 0.99^{120} = 0.3$ as in de la Croix and Michel (2002). The relative preference for environmental quality in old age η is set at 0.9 such that consumption is slightly more important than environmental quality for the old agent. The Frisch elasticity of labor supply $1/\sigma$ is set at 0.4 which is well within the interval obtained from microeconometric estimates (see, MaCurdy, 1981; Altonji, 1986). This implies a value for σ equal to 2.5. Following the estimates of Alvarez-Cuadrado et al. (2016), the parameters governing the intensity of habits and aspirations are all set at the same value equal to 0.33. Concerning the production function, we choose a standard Cobb-Douglas formulation, $F(k_t, n_t) = Ak_t^{\alpha} n_t^{1-\alpha}$, where $\alpha = 0.33$ in accordance with the RBC literature. We also set the depreciation rate of capital δ at one which is not an unrealistic assumption given that one period of the model is equivalent to 30 years. For the parameters governing the evolution of environmental quality

we choose to set $\kappa_c = 0.1$ and $\kappa_m = 0.2$. The value of κ_c implies that one tenth of total consumption is transformed into pollution. We assume that κ_m is relatively larger since m_t consists of specific resources allocated in order to increase environmental quality while consumption generates pollution as an externality. In order to ensure positive maintenance investment at each period in the competitive equilibrium, we set $b = 0.4$ and $\overline{E} = 0.04$. Starting with an initial environmental quality lower than its natural level, the latter recovers naturally at the rate $0.4(0.04 - E_t)$. In our second best setting, the government needs to finance a given stream of public expenditures and we fix the public spending over output ratio at 0.23 which represents the average public spending in 14 of the EU-15 countries over the period 1997-2005 as computed by Trabandt and Uhlig (2011).[1] We also use the computations of Trabandt and Uhlig (2011) for the tax rates on consumption, capital and income used in our competitive economy and obtain the following values: $\tau^c = 0.17$, $\tau^r = 0.33$ and $\tau^w = 0.41$. We furthermore assume that $\tau^m = 0$ so that in the competitive equilibrium, the government does not subsidize maintenance investment. Finally, we need to set a value for the social discount factor used by the planner and we consider the quasi-golden rule case where $\zeta = 0.99$. The values for the different parameters are summarized in Table 1.

Table 1: Value for the parameters

θ	1	κ_c	0.1
ϵ	2	κ_m	0.2
β	0.3	b	0.4
η	0.9	$\overline{E}$	0.04
σ	2.5	g	0.23
ρ	0.33	τ^c	0.17
A	3	τ^r	0.33
α	0.33	τ^w	0.41
δ	1	τ^m	0
ζ	0.99		

4.2 Stabilization policy

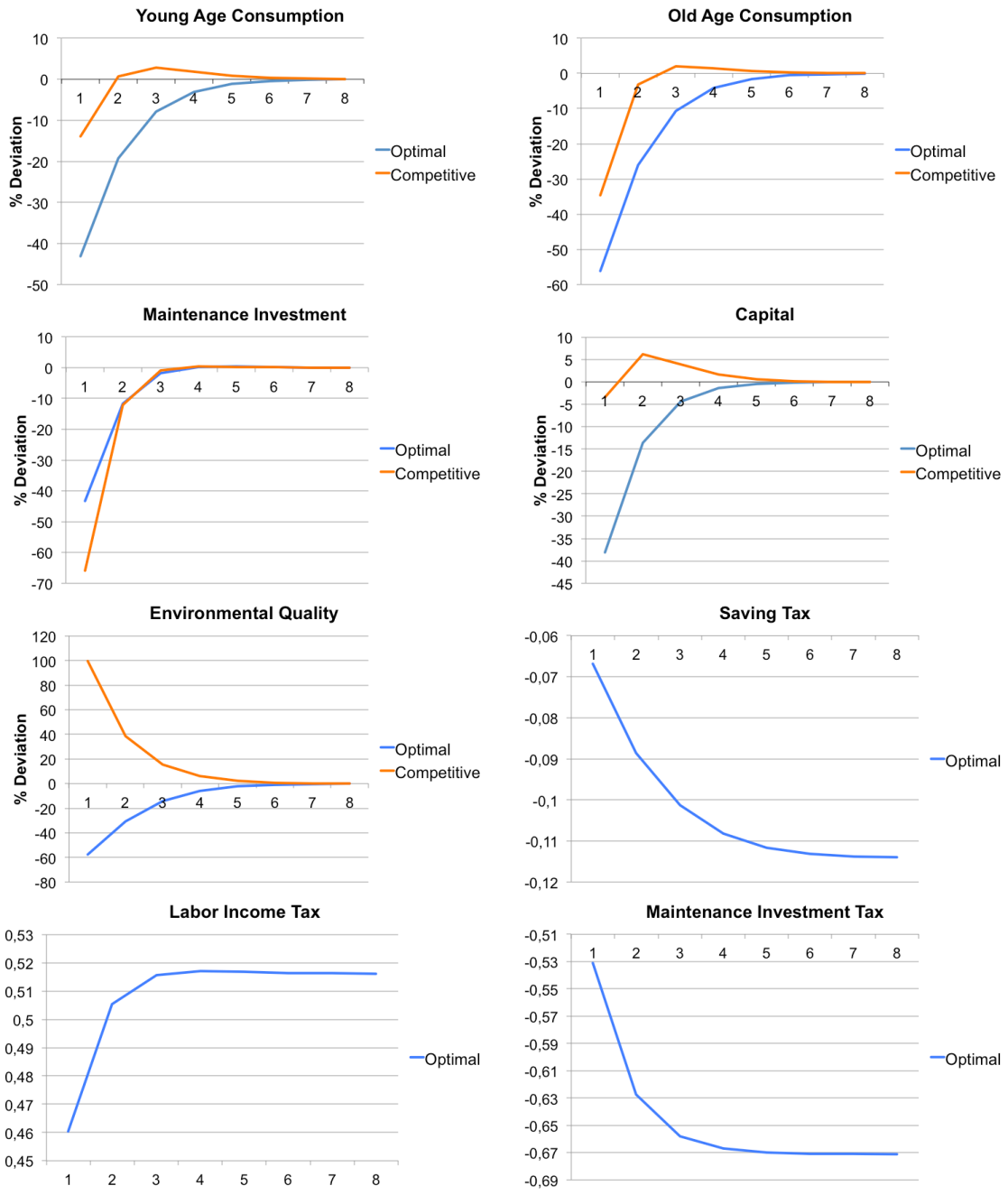
In this section, we numerically simulate the competitive and the optimal allocations in order to show that an appropriate fiscal policy can be used as an effective stabilization device in our setting. We need to set some initial values

[1]The authors exclude Luxembourg due to unavailable data.

for the state variables (k_0,E_0,c_{-1}) and we choose 10% of the steady-state values in both economies. We then simulate the dynamic paths of endogenous variables for both the competitive and the optimal allocations and present the results as percentage deviations from the steady-state in Figure 1. Concerning the competitive equilibrium, we observe that consumption of both generations and capital exhibit cyclical behavior leading to overshooting with respect to the steady-state outcome. Capital only accumulates in the first periods since at some point in time, the intensity of aspirations (in young age consumption and old age environmental quality) induce the agent to save less in order to spend more resources on current consumption as well as on maintenance investment. The economy then faces a drop in savings inducing a recession until the economy stabilizes at the steady-state. It should be noted that this behavior takes place despite the presence of habit formation whose impact is more than compensated by the intensity of aspirations. Environmental quality decreases monotonically during the transition despite increasing maintenance investment. This is not incompatible with an increase in lifetime utility since a decrease in environmental quality also implies lower environmental aspirations in the future. Consumption of both the young and the old is at first increasing but the decrease in savings due to the intensity of aspirations implies a drop in consumption when the recession starts and a subsequent stabilization at the steady-state. The depressing effect that aspirations exerts on savings explains the cyclical behavior that can be observed in the present model. Non-monotonic convergence in models with aspirations is not a surprising result and has been studied before by de la Croix (1996), de la Croix and Michel (1999) or Schumacher and Zou (2008) for example. In the following we show that our optimal path is able to neutralize this cyclical behavior and can be used as an effective stabilization device.

The optimal allocation is characterized by monotonic convergence to the steady-state for all endogenous variables. In order to avoid cyclical behavior, the planner lowers the rise in aspirations by accumulating more capital which allows her to obtain a smooth transition to the steady-state. The increase in capital generates additional resources available for maintenance investment and contrary to the competitive equilibrium, the optimal allocation exhibits accumulation of environmental quality during the transition. The need to refrain the aspirations of the agents implies that the optimal tax rates must induce the latter to increase savings in order to decentralize the planners' solution.

Figure 1:
Dynamic adjustment for the competitive and the optimal economy
Percentage deviations from steady-state (except for tax rates)



4.3 Optimal tax rates

In this section, we compute numerically the paths of the tax rates that decentralize the optimal allocation as a competitive equilibrium. As explained before, we fix our consumption taxes τ^c at 0.17 to be able to compute the rest of the tax rates. The dynamic behavior of the latter are presented at the bottom of Figure 1 and contrary to the endogenous variable are not percentage deviations from the steady-state. In order to decentralize the optimal outcome with fixed consumption taxes, the government needs to implement both a maintenance and an investment subsidy during the transition as well as at the steady-state. The subsidy to maintenance investment increases monotonically towards the steady-state and reaches a value around 67% which indicates the key role that the government has to play concerning the preservation of environmental quality. The importance of the subsidy may however be related to the small regeneration rate that we have chosen ($b = 0.4$ and $\overline{E} = 0.04$) in order to ensure positive maintenance investment at each period in the competitive case. The fact that consumption taxes are constant combined with large maintenance subsidies generate the need to subsidize as well capital accumulation which is in line with the results derived in Corollary 1. The investment subsidy is also monotonically increasing reaching a steady-state value around 11.5%. The magnitude of the latter is relatively important if we consider the value of the tax rates on capital in European economies, however, several remarks are in order concerning our framework. First, the fact that consumption taxes are fixed does not allow us to use this instrument in order to reallocate capital across time. Second, we study a framework with homogeneous individuals within a given generation implying that we discard any intragenerational issue that could induce different subsidies for poor and rich agents. Our main message is that while environmental degradation requires a state intervention under the form of subsidies to maintenance investment, this policy will probably need to be complemented with a subsidy on capital accumulation or at least a reduction in current capital taxes. In order to finance public spending, it is then necessary to rely on sufficiently large income taxes. The latter increase monotonically before reaching a steady-state value close to 52%. Once again, these large income taxes are partially due to the inability to modify consumption taxes which are also used to finance public expenditures. The main result that we obtain by computing the optimal taxes rates is that both maintenance investment and capital should be subsidized in order to decentralize the optimal outcome while public expenditures should be financed trough consumption and income taxes.

5 Conclusion

This paper analyses optimal fiscal policies in an OLG model where preferences include habit formation and inherited aspirations. We focus on second best policies in a setup where the government needs to finance a given stream of public expenditures. On the theoretical side, we derived necessary and sufficient conditions under which the competitive equilibrium is characterized by levels of capital and environmental quality that are too small and a level of labor supply that is too large. We also have shown that policies reducing pollution (taxes on consumption and subsidies to maintenance investment) tend to increase the need to subsidize the capital stock in order to ensure convergence towards the modified golden rule.

Our quantitative illustration allowed us to show that an appropriate fiscal policy can be used as an effective stabilization device for our competitive economy where consumption and capital exhibit an hump-shaped pattern. We also computed the optimal paths of tax rates by fixing consumption taxes and obtained a policy where both maintenance and investment are subsidized while income and consumption taxes finance the latter subsidies as well as a constant share of public expenditures over output.

In the present paper, we have focused on the case of a representative generation ruling out the possibility of intragenerational heterogeneity. It would be interesting to focus next on the introduction of different types of agents allowing us to study redistribution policies. This topic is on our research agenda.

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Appendix

A The planner's problem

With our specific utility function, the implementability constraint for generation t is

$$\frac{\theta c_t}{c_t - \rho_c c_{t-1}} + \frac{\beta\eta(\kappa_m m_t - \kappa_c c_t)}{E_{t+1} - \rho_e E_t} + \frac{\beta\theta d_{t+1}}{d_{t+1} - \rho_d c_t} - \epsilon n_t^{1+\sigma} = 0.$$

The objective function W^t for generation t is then given by

$$W^t = U + \mu_t \left[\frac{\theta c_t}{c_t - \rho_c c_{t-1}} + \frac{\beta\eta(\kappa_m m_t - \kappa_c c_t)}{E_{t+1} - \rho_e E_t} + \frac{\beta\theta d_{t+1}}{d_{t+1} - \rho_d c_t} - \epsilon n_t^{1+\sigma} \right].$$

The derivatives of W^t with respect to our endogenous variables in this specific case are

$$\begin{aligned}
W^t_{c_t} &= \frac{\theta}{c_t - \rho_c c_{t-1}} - \mu_t \left[\frac{\theta\rho_c c_{t-1}}{(c_t - \rho_c c_{t-1})^2} + \frac{\beta\eta\kappa_c}{E_{t+1} - \rho_e E_t} - \frac{\beta\theta\rho_d d_{t+1}}{(d_{t+1} - \rho_d c_t)^2} \right], \\
W^{t+1}_{c_t} &= -\frac{\theta\rho_c[c_{t+1}(1-\mu_{t+1}) - \rho_c c_t]}{(c_{t+1} - \rho_c c_t)^2}, \\
W^t_{d_{t+1}} &= \frac{\beta\theta}{d_{t+1} - \rho_d c_t} - \frac{\mu_t \beta\theta\rho_d c_t}{(d_{t+1} - \rho_d c_t)^2}, \\
W^t_{n_t} &= -\epsilon n_t^{\sigma}[1 + \mu_t(1+\sigma)], \\
W^t_{m_t} &= \frac{\mu_t \beta\eta\kappa_m}{E_{t+1} - \rho_e E_t},
\end{aligned}$$

$$
\begin{aligned}
W^{t}_{E_{t+1}} &= \frac{\beta\eta}{E_{t+1}-\rho_e E_t} - \frac{\mu_t \beta\eta(\kappa_m m_t - \kappa_c c_t)}{(E_{t+1}-\rho_e E_t)^2}, \\
W^{t+1}_{E_{t+1}} &= -\frac{\beta\eta\rho_e[E_{t+2}-\rho_e E_{t+1} - \mu_{t+1}(\kappa_m m_{t+1} - \kappa_c c_{t+1})]}{(E_{t+2}-\rho_e E_{t+1})^2}.
\end{aligned}
$$

Table 1: Value for the parameters

θ	1	κ_c	0.1
ϵ	2	κ_m	0.2
β	0.3	b	0.4
η	0.9	$\overline{E}$	0.04
σ	2.5	g	0.23
ρ	0.33	τ^c	0.17
A	3	τ^r	0.33
α	0.33	τ^w	0.41
δ	1	τ^m	0
ζ	0.99		