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Endogenous Preferences for Parenting and Macroeconomic Outcomes

Abstract

This paper investigates the effects of parenting time on macroeconomic outcomes and welfare when parenting choices are determined by own childhood experience and social norms in an overlapping generations framework. Parenting time and material expenditures on children generate children's human capital. When the share of parenting time is relatively low and parenting and leisure are complements or weak substitutes the model has two steady-state equilibria with different welfare levels. In the high-welfare equilibrium parents have stronger endogenous taste for parenting and spend more time with children and less in paid work. Higher productivity due to the higher human capital more than compensates for the reduction in working hours, leading to a higher output level, in comparison to the low-welfare equilibrium.

JEL-Codes: D910, J130.

Keywords: endogenous preferences, parenting, time use, overlapping generations, human capital.

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1 Introduction

Economics has long recognised the importance of family decisions for macroeconomic performance of a country. The contributions of family economics to macroeconomics were outlined by Gary S. Becker in his Presidential Address to the American Economic Association (Becker, 1988). Since then, family macroeconomics, where family decisions are incorporated in macroeconomic models, has firmly established itself as a field in the discipline (Doepke and Tertilt, 2016).

Much of the economic literature on family decisions has traditionally focussed on parents' material investment in children, such as education expenditures. However, time that parents spend with their children is no less important. More recent studies turned to the role of parenting time in the development of children's skills and abilities, and, hence, their future labour productivity. Rapidly growing empirical literature on time use and theoretical studies concentrate primarily on the optimal decision of time allocation within a family. The research questions include the choice of parenting time and search for its socio-demographic and economic determinants and consequences.[1]

In this paper I aim to investigate the effect of parenting time on macroeconomic outcomes and welfare when parenting choices are determined by own childhood experience and by social norms. I develop a theoretical model of time allocation by working parents where parenting helps to develop children's human capital and at the same time increases parents' utility. The novel feature of the model is the combination of the parenting time as an input into the generation of human capital with the endogenous formation of the taste for parenting. The parenting preferences are formed in the process of *intergenerational transmission* from parents to their children and *intragenerational transmission* across households. I demonstrate that the model can exhibit multiplicity of long-run equilibria. Specifically, for a realistic calibration of the model parameters, two equilibria with different welfare levels can emerge in the long run. The equilibrium with higher welfare is associated with more time with children and stronger taste for parenting than the equilibrium with lower welfare. The high-welfare equilibrium is also characterised by more leisure, fewer working hours, higher human capital and labour productivity, and higher output, than the low-welfare equilibrium. Thus, in the long run time with children is positively associated with parents' human capital. The multiplicity of equilibria suggests a role for a welfare-improving public policy. I explore a welfare-improving tax-transfer policy and show that in this economy its effect on parenting choices depends on whether the economy is in the high- or in the low-welfare equilibrium.

This paper relates to two strands of the literature. First, it relates to the literature on the *endogenous transmission of preferences*.[2] I model preferences for parenting as evolving endogenously, in a dynamic interaction between its individual and social determinants. Time spent with children is as much a family as a social activity. Therefore, it is influenced both by parents' own childhood experience and by social norms, either economy-wide or in the parents' social network or neighbourhood. I model this as a combination of inter- and intragenerational transmission of preferences. The *intergenerational* transmission means that a parent's taste for time with her child is at least partly determined by that of her own

[1] See Monna and Gauthier (2008) and Aguiar et al. (2012) for a comprehensive survey of the literature.

[2] See Bizin and Verdier (2010) for a survey and Doepke and Zilibotti (2017) for an application to parenting styles.

parent. This can be interpreted either as children inheriting the genotype associated with certain parenting behaviour ('direct' genetic effect) or as children evoking and imitating their parents' behaviour consistent with their genotype ('indirect' genetic effect).[3] In addition, the taste for parenting is also partly shaped by the observation of parenting behaviour by peers. This represents the *intragenerational* transmission.

Second, the paper relates to the literature on equilibria with strategic complementarities.[4] In my model parents derive higher utility from spending time with children when they see other parents spending more time with their children. Introducing the effect of a social norm of parenting into the time use decision highlights an additional channel through which parenting time is linked to the aggregate outcomes. A parent spending more time with her child increases the average parenting time observed by all other parents, which raises their utility. In other words, an individual choice of a parent exerts a positive external effect on all other parents, and there is a complementarity of individual parenting choices. The positive effect of one's individual contribution upon aggregate parenting behaviour results in a coordination problem and leads to the possibility of multiple equilibria that can be Pareto-ranked. Numerical solution for a calibrated model shows that in the economy there may exist two long-run equilibria with different levels of welfare. Thus, two economies with identical fundamentals can produce different economic outcomes in the long run. This coordination problem suggests that there is room for welfare-improving government policies.

Therefore, I analyse the effect of a fiscal policy in which tax is imposed on labour income and is used to finance lump-sum transfers to working parents (as a universal child benefit) and to the retired (as a universal state pension). The numerical exercise shows that an increase in the share of child benefit in the total transfer achieves an increase in welfare in both the high- and the low-welfare equilibria.

At the same time, the effect of this welfare-improving policy on parenting time is opposite for the two types of equilibria. In the high-welfare equilibrium increasing the proportion of child benefit in the mix of transfers leads to more time with children. This effect is stronger when parenting time and leisure are complements. The welfare loss caused by distortionary tax on labour income is relatively small and is lower, the higher is the proportion of child benefit in the policy mix. The picture is different in the low equilibrium: the larger the proportion of revenue used for child benefits, the less time is spent with children. The deadweight loss from tax is relatively large and is not very sensitive to the policy mix. It is significantly larger when parenting and leisure are complements compared to the case of substitutes.

In the next section I outline the empirical evidence in support of the two main model assumptions. Section 3 gives a brief overview of the related theoretical literature. Section 4 presents the setup and the solution of a theoretical model. The results are reported in Section 5. Some potential extensions of the model are outlined in Section 6, and Section 7 concludes.

[3] See Klahr and Burt (2014) for an overview of empirical evidence in behavioural genetics literature.

[4] Coordination problem in the context of strategic complementarities was formalised by Cooper and John (1988).

2 Empirical evidence

The two main assumptions of the model are motivated by empirical evidence of (1) the role of parenting time in children's human capital and (2) the individual and social determinants of parenting behaviour.

2.1 Parenting time and children's human capital

The empirical literature provides ample evidence supporting the model assumption that parenting time contributes to children's human capital. Haveman and Wolfe (1995) gave a comprehensive review of earlier empirical studies of the determinants of children's college attainment, based on the U.S. panel data, such as the Current Population Survey (CPS), Michigan Panel Study of Income Dynamics (PSID), National Longitudinal Survey (NLS), and National Longitudinal Survey of Youth (NLSY). One of the robust findings supported by all studies reviewed by Haveman and Wolfe (1995) was that children of working mothers tend to have slightly lower educational attainment, which might be explained by less time working mothers spend with children.

Bryant and Zick (1996), using diary data on parents-children shared time from 1977-78 Eleven-State Time-Use Survey (ESTUS),[5] established positive effect of the parent-child shared time on the stimulation of child's human capital development. Ruhm (2008) found a strong negative correlation between maternal labour supply and children's cognitive development, based on the NLSY data for multiple years. His explanation of the positive or neutral effect found in the previous studies is that they only crudely controlled for heterogeneity in child and household characteristics. He argued that children of working parents have advantaged family backgrounds and attributes conducive to cognitive development.

More recently, Ermisch and Francesconi (2013), using the data from the first seven waves (1991–1997) of the British Household Panel Survey (BHPS), found significant and economically meaningful negative effect of mother's time in full-time work on children's attainments in A-level qualifications.[6] In a more fine-grained analysis of different time uses recorded in the 2003-2011 American Time Use Survey (ATUS) and the Child Development Supplement (CDS) of the PSID for 1992, 2002, and 2007, Heiland et al. (2017) found that maternal employment reduces mothers' quality time with children. Agostinelli and Sorrenti (2018) analysed the effect of maternal employment and income separately on cognitive and behavioural development of children. They found that an increase in income has positive effect but only on cognitive development, whereas an increase in maternal labour supply has negative effect on both cognitive and behavioural child development. This findings were based on 1979 NLSY matched to the children section which tracked the data on children, including their educational achievements, from 1986 until 2014.

To summarise, empirical studies appear to suggest that, by and large, a child's human capital development is positively associated with mother's childcare time and negatively associated with mother's time at work.

[5] The analysis was restricted to the states of Louisiana, New York, Wisconsin, and Utah by the availability of data on shared time in ESTUS.

[6] In Britain, A-level qualification is above the compulsory high school level but below the university level. Certain A-level attainments are required for university entrance.

2.2 Individual and social determinants of parenting behaviour

The second assumption states that parenting behaviour is driven by a combination of inherited and social factors. This is supported by empirical findings in behavioural genetics, sociology, psychology, and economics.

2.2.1 Intergenerational transmission

The behavioural genetics literature has documented strong evidence of heritability of parenting behaviour, including both positive and negative traits, such as 'warmth' and 'harshness'. A meta-analysis by Klahr and Burt (2014) catalogued the extent of genetic and environmental effects on parenting reported in 56 studies. Wertz et al. (2018) used genetic data matched with the home-visit measures of parenting in their study of parental investment in children's educational attainment. The authors emphasized the importance of considering both the genetic and the environmental transmission when interpreting parents' effects on children. Ulbricht and Niederhiser (2009) reviewed the empirical evidence of the interaction between genetic and environmental influences on family relationships, including parenting.

There are numerous studies of the intergenerational transmission of parenting in the psychology literature. Conger et al. (2009) in the concluding remarks to the *Special Section: The Intergenerational Transmission of Parenting* of the *Developmental Psychology* journal noted that '*... the evidence for intergenerational continuity in parenting is robust across diverse study samples, different types of measurement, different lengths of time, and after the introduction of a variety of control variables*' (p. 1276).

2.2.2 Social and cultural norms

The effect of social norms on parenting has long been noted in sociology and psychology. Belsky (1984) argued that parenting is determined by a variety of factors, including ethnicity and community, in addition to the personalities of parents and children. O'Brien Caughy et al. (2001), using the data from two community surveys conducted in Baltimore area in 1994 and 1996, found that the neighbourhood norms are an important determinant of perception and attitudes to parenting. Moreover, in their study differences in the neighbourhood characteristics explained a large proportion of differences in parenting perception associated with individual characteristics. Kotchick and Forehand (2002) reviewed a large body of the literature in developmental psychology and sociology on the empirical evidence of the relationship between parenting and several social context factors, notably, neighbourhood and community.

Similar findings at a larger population scale have been reported in cross-country studies. Joesch and Spiess (2006) investigated cross-country differences in the amount of time mothers spend with their children, using data on nine European countries from the 1996 wave of the European Community Household Panel (ECHP).[7] They found that only a small portion of these differences is explained by variation in socio-demographic characteristics and employment status, whereas country-specific policies aimed at reconciling parenthood and

[7]The nine countries included in this study were Austria, Denmark, Germany, Greece, Ireland, Luxembourg, the Netherlands, Spain, and the United Kingdom. For five other countries participating in the 1996 ECHP (Belgium, Finland, France, Portugal, and Italy) the data on some variables were scarce or unavailable.

employment appear to explain some of the differences. Similarly, Hook and Wolfe (2011), using four national time-use survey data (ATUS for 1993, Germany's Time Use Survey for 2001-2002, Norway's Time Use Survey for 2000-2001, and the UK's National Survey of Time Use for 2000-2001), found that differences in time spent by working parents with children are sensitive to country context. This suggests the importance of social and cultural norms, not captured by economic and policy variables used in these studies.

Based on this evidence, in the model I assume that a parent's preference for time with her child is a function of her own parent's preference and of the current social norm of parenting time.

3 Theoretical literature

The model in this paper builds on the large body of theoretical work, pioneered by Becker (1981), on the role of family in the formation of human capital and its effect on macroeconomic performance.

In the baseline framework in the family macroeconomics literature, parents care about well-being of their children and devote part of their time and wealth to children to raise their future endowment and labour earnings. The amount of physical and time resources invested in children is determined by parents' budget and time constraints and by their preferences. Parents' time devoted to children reduces time in paid employment and leisure, and so presents an opportunity cost. Also, parents' decisions affect their children's decisions in the future only *indirectly*, by changing their *endowments* in material wealth or in human capital. Fernandez et al. (2004) introduced a particular form of the *direct effect on preferences*, as an additional explanation of the increased female labour market participation. In their model, mother's choice of time allocated to paid work affects son's marital preferences. As a result, if son of a working mother is more likely to marry a working woman, then women are more likely to work and to invest in their labour market skills.

Transfer of resources within a family, in the form of bequests and time used for production of home good, was explored in Cardia and Ng (2003) and Cardia and Michel (2004), in an overlapping generations framework with altruism. In these studies the focus is on the link between altruism and transfer of time and bequests as different types of resources. Parents' time spent with children does not affect children's future productivity. Casarico and Sommacal (2012, 2018) modelled childcare as an intermediate good produced at home, using parents' time and physical good, such as childcare expenditures, where the marginal productivity of parents' time increases in parents' human capital. The authors used this framework to assess the effects of labour income taxation and childcare subsidies on growth under the assumptions of paternalistic and pure (Beckerian) altruism.

4 The model

I depart from the literature by modelling the effect of parents' choice on the future choice of their children both via the change in human capital *endowment* and via transmission of *preferences*, and by adding *social norms* in the form of a peer effect on parenting preferences.

A framework for endogenous determination of preferences via intergenerational cultural transmission was formalised by Bisin and Verdier (2001, 2010). In this framework parents socialise their children to their own preference traits. Children's preferences are formed under the influence of this socialisation by parents combined with the influence of the cultural and social environment. This approach, in particular, was applied to the evolution of different parenting styles by Doepke and Zilibotti (2017) and further developed for the analysis of parenting choices by Doepke, Sorrenti and Zilibotti (2019).

My approach is different in that parents do not invest resources deliberately in the formation of their children's preferences. The first, intergenerational part of the transmission mechanism can be described as a pure imitation or a hereditary trait. The second, intragenerational part is a social norm formed by aggregate behaviour of all families in the society. I assume that a parent enjoys each minute spent with her child stronger, the more time other families in the same cohort spend with their children.

In this setting I investigate the properties of the long-run macroeconomic and welfare outcomes of the parents' choices and how these outcomes depend on the exogenous parameters in preferences and technology. I also investigate how welfare and macroeconomic variables are affected by a tax-transfer policy whereby government provides unconditional transfers to households funded by labour income tax.

4.1 The setup

I consider an infinitely-lived economy with overlapping generations. Each individual lives three periods: as a child, as an adult working parent, and as an old retiree. Agent t is born in period $t-1$, works and reproduces in period t, and retires in period $t+1$. All agents in the same cohort are identical, each adult agent has one child, and so the population is constant. There is no uncertainty, and the agents have perfect foresight. There is one physical good produced using capital and labour as inputs. It can be used either as investment or as consumption good. Each adult agent t is endowed with one unit of time that can be used for leisure (ℓ_t), paid employment (L_t) in the production sector, and unpaid parental care (τ_t). Income after taxes and transfers is divided between parent's own consumption (c_t), savings (s_t), and material expenses on a child (q_t), which can be interpreted as expenditure on child's consumption, formal childcare or schooling. The labour productivity, or the level of human capital of an adult agent is determined by the amount of consumption and parental care they received in childhood, $H_t = h(q_{t-1}, \tau_{t-1})$. Savings are invested in production by the means of a perfect capital market. Old agents use the gross return on their savings made in the previous period, along with any transfers from the government, to fund their consumption, x_{t+1}.

4.1.1 The government

The government taxes labour income at a constant flat rate of t_L and uses tax revenue to fund two unconditional transfers. Each working parent at time t receives cash in the amount of P_t, and when retired at time $t+1$ she receives R_{t+1} in cash. To isolate the effect of the mix (different timing) of transfers I assume that the transfers are lump-sum. These transfers can be interpreted as a universal child benefit and a universal state pension. The

government runs balanced budget in every period. Thus, denoting tax revenue at time t by T_t and denoting the proportion of tax revenue paid out as child benefit by ω_t, we have $P_t = \omega_t T_t$ and $R_t = (1 - \omega_t) T_t$. The allocation of tax revenues between the two programmes, $\omega_t \in [0, 1]$, is a policy variable.

4.1.2 Preferences

The preferences of an adult who is a working parent at time t are characterized by Beckerian altruism described recursively by a utility function of the form

$$W_t = U_t + \beta W_{t+1}, \tag{1}$$

where W_t is the well-being of the parent, U_t is the parent's life-cycle utility, W_{t+1} is the well-being of the child, and the degree of altruism towards the next generation is measured by $\beta \in (0, 1)$. Assuming that life-cycle utilities are bounded, the well-being of an adult at time t can be expressed as an infinite discounted sum of life-cycle utilities of her own and all future generations,

$$W_t = \sum_{i=0}^{\infty} \beta^i U_{t+i}, \tag{2}$$

Therefore, in this formulation, the representative dynasty is similar to an infinitely-lived representative agent.

I further assume that the life-cycle utility is an increasing and concave function of consumption in two periods, leisure, and parenting time,

$$U_t = U\left(c_t, x_{t+1}, \ell_t, \varepsilon_t \tau_t\right). \tag{3}$$

Preference parameter $\varepsilon_t \geq 0$ measures the importance of time with children in parents' utility, or the strength of parenting preferences of an adult at time t.

Preference for parenting time of an adult in the current generation are determined both by the preference of this adult's parent and by the current social norm for parenting. Taste for parenting is at least partly inherited. Alternatively, one can think of a parent being a role model imitated by a child when she, in turn, becomes a parent. The current social norm is reflected in the prevalent pattern of parenting behaviour, measured by the societal average of parenting time. I assume that ε_t follows a 'partial adjustment' process with drift bounded between zero and some positive number $\overline{\varepsilon}$:

$$\begin{aligned} \varepsilon_t &= \min\left\{\overline{\varepsilon}, \max\left\{0, \mu\varepsilon^* + (1-\mu)\,\varepsilon_{t-1} + \varphi\left(\overline{\tau}_t\right)\right\}\right\}, \\ \mu &\in [0, 1]\,, \overline{\varepsilon} \geq \varepsilon^* \geq 0. \end{aligned} \tag{4}$$

Here ε^* is an exogenous 'benchmark' parameter, $1 - \mu$ measures the extent of heritability of taste for parenting, $\overline{\tau}_t$ is the average parental childcare time across all adults at time t, and $\varphi(\cdot)$ is the drift function such that $\varphi(0) = 0$ and $\varphi' > 0$. The term $\varphi\left(\overline{\tau}_t\right)$ captures the current social norm in parenting time, or the peer pressure. In the interior

$$\varepsilon_t - \varepsilon_{t-1} = \mu\left(\varepsilon^* - \varepsilon_{t-1}\right) + \varphi\left(\overline{\tau}_t\right), \tag{5}$$

Assumption (4) links parenting behaviour across generations directly, from a parent to her child, and indirectly, via a peer effect, where peer's parenting attitudes were influenced by their parents who belonged to a similar social environment (Calvo-Armengol and Jackson, 2009). Each parent takes the social norm as given, ignoring their own contribution into the societal average.

4.1.3 Household decision

Agent t's time constraint is

$$L_t + \ell_t + \tau_t \leq 1. \tag{6}$$

There is no direct material cost associated with time spent with children. The budget constraints at time t and $t+1$,

$$\begin{aligned} c_t + q_t + s_t &\leq [1 - t_L]\, w_t H_t L_t + P_t, & (7)\\ x_{t+1} &\leq (1 + r_{t+1})\, s_t + R_{t+1}, & (8) \end{aligned}$$

combine into the life-time budget constraint,

$$c_t + q_t + \frac{x_{t+1} - R_{t+1}}{1 + r_{t+1}} \leq [1 - t_L]\, w_t H_t L_t + P_t. \tag{9}$$

Here w_t is the competitive wage rate per efficiency unit of labour, and r_{t+1} is the net return on savings. The Lagrangean of the intertemporal optimisation problem at time 0 can be written as

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \left[U\left(c_t, x_{t+1}, \ell_t, \varepsilon_t \tau_t\right) + \lambda_t \left([1 - t_L]\, w_t H_t L_t + P_t - c_t - q_t - \frac{x_{t+1} - R_{t+1}}{1 + r_{t+1}} \right) \right], \tag{10}$$

with some initial conditions $\{H_0, x_0, \varepsilon_0\}$. At time t, the state variables are $\{H_t, x_t, \varepsilon_t\}$, and the optimal choice is made for $\{L_t, \ell_t, \tau_t, c_t, q_t, x_{t+1}\}$ subject to the time and budget constraints. The prices of labour and capital and the policy variables are taken as given in every period.

4.1.4 Production sector

The production sector consists of a large number of identical competitive firms producing a single physical good. The production technology has constant returns to scale in physical capital and labour augmented by human capital,

$$Y_t = F\left(K_t, H_t L_t\right), \tag{11}$$

and so the sector can be replaced by a representative firm. The representative firm takes the wage rate and the rental price of capital as given and chooses capital and labour inputs in every period to maximize profit,

$$\pi_t = Y_t - w_t H_t L_t - r_t K_t. \tag{12}$$

The physical capital depreciates at rate δ, and so the law of motion of physical capital is

$$K_{t+1} = (1 - \delta)\, K_t + s_t \tag{13}$$

with some initial value K_0.

4.2 Dynamic equilibrium

The dynamic equilibrium is defined as the sequence $\{K_t, L_t, H_t, c_t, q_t, x_t, \ell_t, \varepsilon_t, \tau_t; \lambda_t, w_t, r_t; P_t, R_t\}_{t=0}^{\infty}$ which solves the optimisation problems of the household and the production sector with given initial conditions, so that the markets for inputs and output clear in every period and the government budget constraint

$$P_t + R_t = t_L w_t H_t L_t. \tag{14}$$

holds in every period. The system of first-order conditions for an interior equilibrium after some manipulations can be written as follows:

$$r_t = \frac{\partial Y_t}{\partial K_t}, \tag{15}$$

$$w_t H_t = \frac{\partial Y_t}{\partial L_t}, \tag{16}$$

$$\frac{\partial U}{\partial c_t} = \frac{\partial U}{\partial x_{t+1}}(1 + r_{t+1}) \tag{17}$$

$$\frac{1}{[1 - t_L] w_t H_t} \frac{\partial U}{\partial \ell_t} = \frac{\partial U}{\partial x_{t+1}}(1 + r_{t+1}), \tag{18}$$

$$\frac{1}{[1 - t_L] w_t H_t} \frac{\partial H_{t+1}}{\partial \tau_t} = \frac{\partial H_{t+1}}{\partial q_t}\left(1 - \frac{\frac{\partial U}{\partial \tau_t}}{\frac{\partial U}{\partial \ell_t}}\right), \tag{19}$$

$$\frac{\lambda_t}{\beta \lambda_{t+1}} = [1 - t_L] w_{t+1} L_{t+1} \frac{\partial H_{t+1}}{\partial q_t}. \tag{20}$$

In equilibrium this system needs to be satisfied along with the budget and time constraints (6) – (9) and (14) which hold with equality. The first two conditions, (15) and (16), equate factor prices in the goods sector to their marginal products. Equations (17) and (18) describe the intertemporal trade-offs on the margin between current consumption and leisure at working age and future consumption at old age. Finally, equations (19) and (20) describe the trade-offs on the margin between unpaid parenting time and leisure (as a foregone labour income) and material spending on child's current consumption (or schooling) as inputs in child's human capital, or her future labour productivity.

4.3 Functional forms

For analytical tractability and further numerical simulations I adopt the following functional forms for preferences and technology. The production function in the goods sector is Cobb-Douglas,

$$Y_t = A K_t^{\alpha} (H_t L_t)^{1-\alpha}, \ 0 < \alpha < 1. \tag{21}$$

The life-cycle utility is separable in consumption and time use:

$$U = \upsilon(c_t, x_{t+1}) + u(\ell_t, \varepsilon_t \tau_t). \tag{22}$$

That is, the marginal utility of consumption in either period is independent of time allocation. Further, the utility of consumption is log-linear and the utility of time use is linear-quadratic:

$$\upsilon(c_t, x_{t+1}) = \phi \ln c_t + \theta \ln x_{t+1}, \ 0 < \theta < \phi, \tag{23}$$

$$u\left(\ell_t, \tau_t\right) = \ell_t + \varepsilon_t \tau_t - \frac{1}{2}\left[\ell_t^2 + 2\gamma \ell_t \varepsilon_t \tau_t + \left(\varepsilon_t \tau_t\right)^2\right]. \tag{24}$$

Parameter $\gamma \in [-1, 1]$ measures the degree of substitutability between leisure and parenting time. Higher positive values of γ reflect higher substitutability, with $\gamma = 1$ corresponding to perfect substitutes. The negative values of γ imply complementarity. I focus on the range of parameters for which in equilibrium the marginal utilities of leisure and parenting time are positive; a sufficient condition is $\varepsilon_t \in (0, 1)$.

In the formation of human capital the material input and parental time can be substitutes or complements. I use a CES production function for human capital, where these two inputs generally have unequal shares and some degree of substitutability:[8]

$$H_{t+1} = B\left[\eta q_t^{\rho} + (1-\eta)\,\tau_t^{\rho}\right]^{1/\rho},\ \rho < 1,\ 0 < \eta < 1. \tag{25}$$

For the drift function in the evolution of parenting preferences I assume linear form,

$$\varphi(\tau) = \varphi_0 \tau,\ \varphi_0 > 0. \tag{26}$$

4.4 Steady state

I focus on the properties of *an interior symmetric steady-state equilibrium*, i.e. an equilibrium where all non-negative endogenous variables are strictly positive and constant, and all individual choices are identical (in particular, $\tau_t = \overline{\tau}$ for all t). Below, the symbols without time indices denote the steady-state values. After some manipulations, the first-order conditions can be stated as follows:

$$\begin{aligned}
\left[L\left[L + \tau\left[1 - \gamma\varepsilon\right]\right]\left[1 + \xi_1\right] - \frac{\phi + \theta}{\xi_2}\right]^{1-\rho} - \xi_0 L^{1-\alpha\rho/(1-\alpha)}\left[L + \left[1 - \gamma\varepsilon\right]\tau\right]^{1-\rho/(1-\alpha)} &= 0, \\
\left(1 + \xi_1 - \beta\right)L^2 + \left(2 + \xi_1 - \beta\right)\left[1 - \gamma\varepsilon\right]L\tau + \left[1 - 2\gamma\varepsilon + \varepsilon^2\right]\tau^2 - \left[1 - \gamma\right]\varepsilon\tau - \frac{\phi + \theta}{\xi_2} &= 0,
\end{aligned}$$

where

$$\varepsilon = \varepsilon^* + \frac{\varphi_0}{\mu}\tau, \tag{27}$$

$$\xi_0 \equiv \beta\eta B^{\rho}\left[\left(1-\alpha\right)\left[1 - t_L\right]A\left[\frac{\theta}{\delta}\right]^{\alpha}\right]^{\rho/(1-\alpha)}, \tag{28}$$

$$\xi_1 \equiv \frac{t_L}{1 - t_L}\left[\omega - \frac{\phi}{\theta}\frac{1-\omega}{1+r}\right], \tag{29}$$

$$\xi_2 \equiv 1 + t_L\frac{1-\alpha}{\alpha}\frac{r}{\delta}\frac{1-\omega}{1+r}, \tag{30}$$

and

$$r = \frac{\alpha}{1-\alpha}\frac{\delta}{\theta\left[1 - t_L\right]}L\left[L + \tau\left[1 - \gamma\varepsilon\right]\right]. \tag{31}$$

The details of calculations are in the Appendix.

[8] Folbre (2006) emphasised that "*both time and money are important 'inputs' into children, and time and money are not perfect substitutes for each other.*"

Parameter	Definition	Value/Range
A	TFP in goods production	10
B	TFP in human capital production	5
t_L	Labour income tax rate	0.24
α	Share of physical capital in goods production	0.33
β	Parental altruism	0.3
γ	Parenting-leisure substitutability rate	-0.2 / $[-1, 1]$
δ	Physical capital depreciation rate	0.75
ε^*	Benchmark strength of parenting preference	0.02
η	Share of material input in human capital production	0.3 / $[0, 1]$
θ	Share of consumption in old age	0.04
μ	Partial adjustment parameter in parenting preference	0.5
ρ	Substitutability parameter in human capital production	0.5
ϕ	Share of consumption in working age	0.05
φ_0	Weight of average parenting time in parenting preference	1
ω	Share of childcare benefit in total transfer	0 / $[0, 1]$

Table 1: Parameters used in the baseline model and in the sensitivity analysis.

4.5 Calibration

For calibration I follow Cardia and Ng (2003), Casarico and Sommacal (2012, 2018), and Garriga (2019), where the estimates are based on the US and European data. I assume that each period is 25 years. All parameters are listed in Table 1.

Taxation. I set the labour income tax rate to $t_L = 0.24$.

Consumption good production. The elasticity of output with respect to physical capital is set to $\alpha = 0.33$ to match the capital share in the national income. The depreciation rate of physical capital is set to $\delta = 0.75$ to match the ratio of aggregate savings to output to $s/Y \simeq 1/4$, and the total factor productivity is set to $A = 10$.

Human capital production. The substitutability parameter is set to $\rho = 0.5$, which implies that the elasticity of substitution between material expenditures and parenting time equals 2. This value is in the range of estimates for the elasticity of substitution between expenditures and time in home production (Aguiar and Hurst, 2007; Aguiar et al., 2012). The total factor productivity is set to $B = 5$. For the share of material expenditures I use $\eta = 0.3$ as a benchmark. In the sensitivity analysis I allow it to vary in the full range between 0 and 1.

Preferences. The weights of consumption in working and old age are set to $\phi = 0.05$ and $\theta = 0.04$, and the altruism parameter is set to $\beta = 0.3$. There is no a priori information about the preference formation process. I use $\mu = 0.5$, $\varphi = 1$, and $\varepsilon^* = 0.02$, to match the equilibrium time allocation as discussed in the next session. For the parenting-leisure substitutability parameter I use $\gamma = -0.2$ (weak complements) as a benchmark. In the sensitivity analysis I allow it to vary in the full range between -1 (strong complements) and 1 (perfect substitutes).

5 Results

5.1 Low-welfare and high-welfare equilibria

I start with the case $\omega = 0$, i.e. with state pensions but no transfers to working parents. The benchmark parametrisation leads to a solution where the shares of time in the adult age dedicated to work, leisure, and parenting are approximately 0.28, 0.63, and 0.09, respectively. These values are close to estimates used by Casarico and Sommacal (2012). Assuming that parenting time is concentrated in the first 12 years of the first twenty-five year period, and that working parents have 100 hours per week available for discretionary use (Cardia and Ng, 2003; Casarico and Sommacal, 2012, 2018), this implies that a parent spends, on average, 18.75 hours per week or about 2.7 hours a day with her child.

It turns out that for the same parametrisation there exists the second equilibrium, where the shares of time allocation are 0.15 for work, 0.41 for leisure, and 0.44 for parenting. The latter amounts to 91.7 hours per week over the first 12 years. While this may appear unrealistically high, one can think of parenting time as including family holidays, shared weekend activities, and all other unpaid time enhancing child's development up until finishing high school at the age of 17. In that case this estimate implies spending with child about 64.7 hours per week.

In the second equilibrium the utility is higher than in the first equilibrium. Thus, I will refer to the benchmark equilibrium as the low-welfare, or the "low" equilibrium, and to the second equilibrium as the high-welfare, or the "high" equilibrium.

To investigate the sensitivity of equilibria to the model parameters I conduct simulations allowing γ and η to vary in their respective full ranges, $-1 \leq \gamma \leq 1$ and $0 < \eta < 1$. The numerical results show that two equilibria coexist over a wide range of parameters, as shown in Figure 1. The high-welfare equilibrium exists for the range of (γ, η) combinations below the solid line (marked by H), and a low-welfare equilibrium exists for the range below the dashed line (marked by L). The two equilibria coexist where these two areas overlap (marked by H+L).

One can see that the low equilibrium exists in almost full range of γ when η is sufficiently low, i.e. when the share of parenting time in human capital production is higher than the share of material expenditures. Moreover, for sufficiently high γ there is only a low equilibrium. This describes the situation where leisure and time with children are strong substitutes, but an hour with child is worth only a small fraction of an hour of leisure, and so parents spend little time with children. On the other hand, for a given η the high equilibrium exists for lower γ, i.e. for weaker substitutability or stronger complementarity between leisure and parenting time in the utility. There is only a high equilibrium when leisure and parenting time are strong complements, provided η is in an intermediate range. Complementarity between leisure and parenting time reinforces incentives to spend time with children when taste for parenting is strong.

Figure 1 also shows that a switch from a low-welfare to a high-welfare equilibrium can take place when η increases, provided that γ is low enough (leisure and parenting are complements or weak substitutes). Suppose, originally the economy is trapped in the low equilibrium with a given γ and some low η. Time with parents has a greater share in children's future labour productivity in a less developed society, where children learn skills predominantly from their

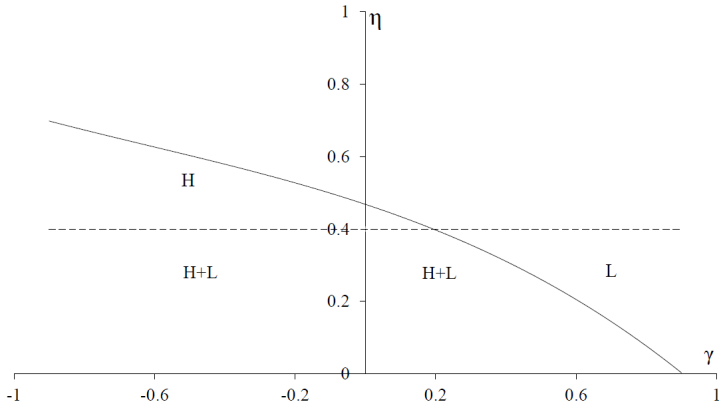


Figure 1: Existence of high (H) and low (L) equilibria over the range of substitutability between leisure and parenting time (γ) and the share of material input in human capital production (η), for $\omega = 0$ (only pensions, no child benefits).

parents. As the society develops, the role of high technologies and specialised equipment in education grows relative to the role of parenting. The share of material input in children's human capital increases, and above the threshold value of η (a point on the dashed line in Figure 1 for a given γ) the low equilibrium disappears, moving the economy towards the high equilibrium.[9] This suggests that the growing importance of material inputs might be contributing to the observed in the recent decades increase in time parents spend with children in many developed countries (Gimenez-Nadal and Sevilla, 2012; Fox et al., 2013).

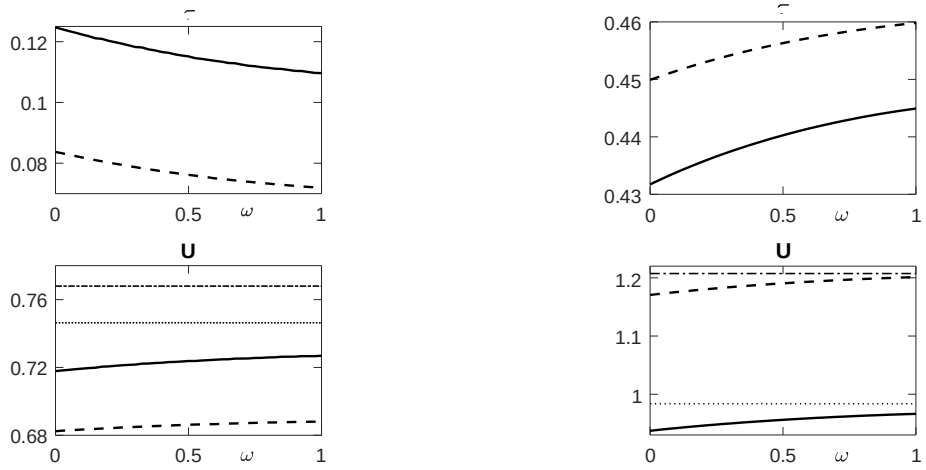
5.2 Strategic complementarity in parenting time

The source of the multiplicity of equilibria is the strategic complementarity in the choice of time with children. When an individual parent spends more time with her child this raises the average parenting time for all parents in the same cohort. Higher societal average parenting time raises the marginal utility of individual parenting time, giving an incentive to spend more time with children. Each individual parent ignores this external effect on other parents. Thus, an economy can be in one of the two equilibria, where the high equilibrium is associated with more time with children and higher utility than the low equilibrium. This is shown in Figure 2, where parenting time (τ) and utility (U) are shown for the low equilibrium in panel (a) and for the high equilibrium in panel (b). To illustrate the robustness of the result τ and U are shown for the full range of policy mix ($0 \leq \omega \leq 1$) and for the cases of substitutability ($\gamma = 1/2$, solid lines) and complementarity ($\gamma = -1/2$, dashed lines) between parenting time and leisure. For the welfare comparison, the dotted (for $\gamma = 1/2$) and dash-dotted (for $\gamma = -1/2$) lines in the lower boxes on each panel of Figure 2 show the utility levels without tax and transfers. The sensitivity analysis of the interior equilibria[10]

[9] Doepke and Zilibotti (2017) analyse the emergence of different parenting styles as a function of the return to education and relate the latter to the degree of inequality in the society. In their model a change in parenting style can occur when the return to education crosses a threshold value.

[10] Available from author upon request.

shows that the results are qualitatively similar in the range of (γ, η) where two equilibria coexist.



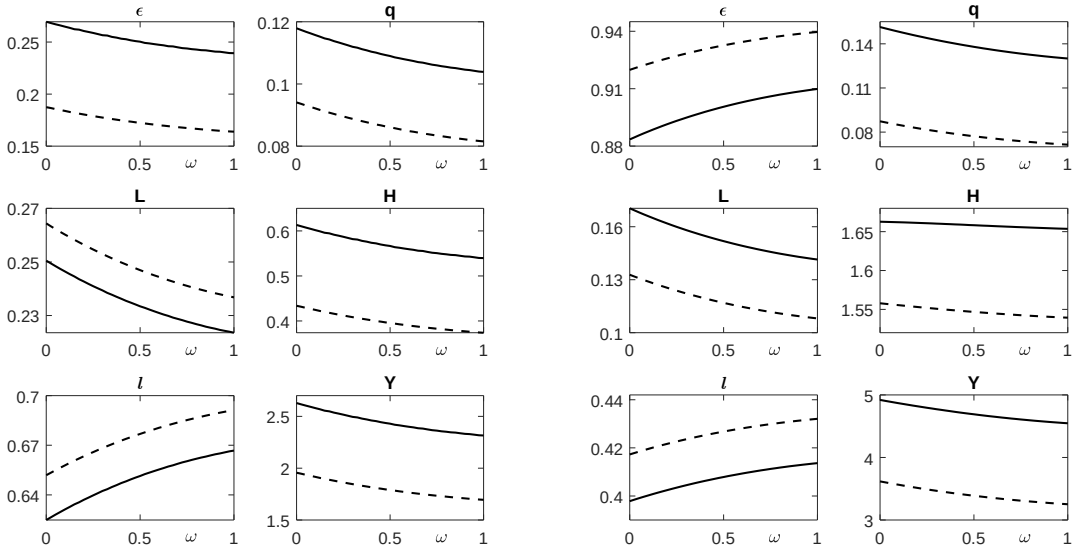
(a) Low equilibrium (b) High equilibrium

Figure 2: Parenting time (τ) and utility (U) in two equilibria when leisure and parenting are substitutes (solid lines) and complements (dashed lines). Utility levels without tax and transfers are shown with dotted (substitutes) and dash-dotted (complements) lines.

5.3 Comparison of economic outcomes

Further analysis shows that in the high-welfare equilibrium preference for parenting is stronger than in the low-welfare equilibrium. Furthermore, the high-welfare equilibrium is also characterised by better economic outcomes. When preference for parenting is strong, parents spend more time with children, which leads to higher human capital and labour productivity. In turn, higher labour productivity leads to higher income and output, in comparison to the low-welfare equilibrium.

Figure 3 illustrates how the outcomes compare between the two equilibria in the benchmark parametrisation for the full range of policy mix ($0 \leq \omega \leq 1$) and for the cases of substitutability ($\gamma = 1/2$, solid lines) and complementarity ($\gamma = -1/2$, dashed lines) between parenting and leisure. The numerical results demonstrate that, while in the high equilibrium time in work is lower than in the low equilibrium, output and earnings are higher due to higher labour productivity. At the same time, leisure is lower in the high equilibrium. Thus, if a society happens to be in a high equilibrium, parents work fewer hours but earn more because of a higher labour productivity. They also enjoy more time with children. Another society, with the same economic fundamentals, can be trapped in an equilibrium with low productivity, low income and welfare, with parents working longer hours and spending less time with children.



(a) Low equilibrium (b) High equilibrium

Figure 3: Strength of preference for parenting (ε), expenditures on child's consumption or schooling (q), time in paid work (L), human capital (H), leisure (ℓ), and output (Y) in two equilibria when leisure and parenting are substitutes (solid lines) and complements (dashed lines).

5.4 Policy mix effect on time allocation

The two steady-state equilibria also differ in the effect of a change in the policy mix upon time allocation. One can see in Figure 2 that, as transfer to working parents increases, the utility increases in both equilibria, but the time with children increases in the high equilibrium and falls in the low equilibrium. The pattern is the same when leisure and parenting time are substitutes or complements. This suggests that child benefits paid to working parents might not always be an effective way of encouraging them to spend more time with children.

The intuition behind this pattern is the following. An increase in the lump-sum child benefits offset by a pension cut has an income effect on the time allocation. As the transfer to working parent expands, they spend less time in paid work. This frees more time for leisure and parenting. If an economy is in the low equilibrium, the taste for parenting is weak. The utility gain from an extra hour of child care is a small fraction of the utility gain from an extra hour of leisure. In the example illustrated in Figure 3 (a) ε is between 0.16 and 0.26. As a result, leisure time increases and parenting time falls. The associated pension cut has an income effect on resource allocation. As the transfer to pensioners shrinks, material expenditures on a child fall, because working parents save more for retirement. The fall in both inputs results in a significant drop in human capital, leading to lower output.

If, on the other hand, the economy is in the high equilibrium, utility gains from parenting and leisure are of the same order of magnitude. In the example illustrated in Figure 3 (b) ε is between 0.86 and 0.94. As the proportion of child benefits in total transfer increases, leisure time increases, but so does parenting time. Material expenditures on children fall,

but because of the increase in parenting time the relative decrease in the human capital and, hence, in the output, is much smaller than in the low equilibrium.

Another interesting property of the two steady-state equilibria is the extent of the welfare loss caused by distortionary taxation. One can see that the welfare loss is not very sensitive to the mix of transfers in the low equilibrium but is noticeably larger when parenting and leisure are complements (between 11 and 12 per cent for $\gamma = -1/2$ against 3 to 4 per cent for $\gamma = -1/2$). In the high equilibrium the welfare loss shrinks significantly (from 5 to 2 per cent for $\gamma = -1/2$ and from 5 to less than one per cent for $\gamma = -1/2$) when the transfer mix is shifted away from pensions towards child benefits. Intuitively, in the high equilibrium the utility gain from an additional hour of parenting time is sufficiently high because of the stronger parenting preference. This gives incentive to spend more time with children, thus resolving, at least partly, the coordination problem. The welfare gain from increased parenting time offsets some of the deadweight loss from taxation.

6 Discussion

In the framework developed in this paper all parents are identical and the focus is on one parent – one child case. The model can be extended in several important aspects to reflect the observed differences in parenting choices across households.

First, one can introduce heterogeneity, for example, in the taste for parenting or in the innate abilities in education. Several empirical studies (Craig, 2006; Chalasani, 2007; Guryan et al., 2008; Dotti Sani and Treas, 2016) have found that higher education and higher income of parents are associated with more time spent with children. Preference for parenting and peer effect combined with the parenting time as a factor in human capital may offer an explanation for the empirically observed educational gradients in parenting time. On the one hand, better educated parents face higher opportunity cost of parenting time because of higher earnings. On the other hand, parents with higher levels of education may be '*... particularly receptive to the current social ideal of attentive, sustained and intensive nurturing*' (Craig, 2006, p. 553). If the positive effect of peer pressure on parenting choice is sufficiently stronger for better educated parents, it can lead to positive correlation between parents' education and time with children, especially if parents with different educational backgrounds belong to different social networks.

Second, the fertility decision can be introduced to capture the observed demographic patterns and the relationship between the parents' human capital and the number of children, as in de la Croix and Doepke (2003). In my model the assumption of one child can be interpreted as the fertility choice that has been made implicitly, at the outset. The fertility decisions matter when parents have different human capital and, therefore, different incomes, but the material cost of investment in children is fixed, and is thus relatively more expensive for low-income families. The effect of social norms on the individual attitudes to parenting can complement the explanation along these lines. The trade-off between children quality and quantity in an environment with heterogeneous human capital among parents in combination with dynamic formation of individual preferences and social norms can give additional insights in the dynamics of inequality.

Third, the effect of parenting time on child's human capital may depend on the alter-

native childcare arrangements used by working mothers. The choice among the available alternatives may also differ, depending on mother's characteristics, and better alternatives may not be available for children in low-income households.[11] The empirical findings by Bernal (2008), Bernal and Keane (2010, 2011), and Dunifon et al. (2013) suggest that while mother's time is an important input in child's cognitive development, high-quality trained formal care can offset or even outweigh the adverse effect of mother being away at work. Thus, trained formal care, as an alternative to mother's time or other informal childcare, can be beneficial especially for children from disadvantaged backgrounds. The relative importance of mother's time and alternative childcare for different types of households can also be investigated in an extended model with heterogenous families.

Fourth, some other family policies can be analysed in this framework, such as the childcare subsidies and state provision of free early care and education (Ruhm, 2011). Combined with heterogeneity, the framework can be used to investigate the differential effect of these policies on parenting choices and children's development for families with different socioeconomic backgrounds, as in Bernal and Keane (2010, 2011).

Finally, there is empirical evidence, reviewed, for example, in Arntz et al. (2017), that time taken off work for parenting can be detrimental to subsequent career and earning prospects, especially for mothers. This additional trade-off between paid work and parenting can be introduced by modelling further accumulation of human capital by working adults. This setup can be used to compare the effect of the parental leave and subsidies to formal childcare on human capital.

7 Conclusion

In this paper I study the effect of family time allocation on macroeconomic outcomes in an overlapping generations model in which parenting choices are determined by own childhood experience and by social norms. Parenting time and material expenditures on children are inputs in children's human capital and, thus, in their future labour productivity. I show that, for a certain range of parameters, the model exhibits two long-run equilibria with two different levels of welfare. Higher welfare and better macroeconomic outcomes are associated with stronger preferences for parenting time, more time spent with children, and more leisure. In the high-welfare equilibrium, higher productivity due to the higher human capital more than compensates for the reduction in working hours, leading to a higher output level, in comparison to the low-welfare equilibrium.

In this setting, I investigate the welfare effect of a government policy of universal transfers to working parents and to pensioners funded by labour income tax revenue. I show that higher share of child benefit in the total transfer increases welfare in both equilibria, while the effect on time allocation depends on the equilibrium state of the economy. If an economy is in the high-welfare equilibrium, an increase in child benefit leads to more parenting time. The opposite is true for an economy in the low-welfare equilibrium.

The simulation analysis of the dynamic equilibrium[12] shows that the model economy converges either to the high-welfare or to the low-welfare equilibrium depending on the

[11] I am grateful to the anonymous referee for directing me to this literature.

[12] Available from author upon request.

initial conditions. This suggests that a policy intervention can be devised in a way that by changing the initial conditions it moves an economy from a low-welfare trap onto the path that converges to the high-welfare equilibrium. One way to change the initial conditions could be to restrict working hours. Indeed, as pointed out by Gornick and Heron (2006), in many developed countries changes in the working time policies leading to lowering the ceiling on weekly working hours in the last two decades were underpinned by a public discourse on work-life or work-family balance. An assessment of the efficiency of such a policy would require an analysis of the transitional dynamics following the policy introduction. The potential of this and other interventions to move the economy to the high-welfare equilibrium is left for future research.

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Appendix

7.1 Notations and functional forms

$$
\begin{aligned}
U\left(c_t, x_{t+1}, \ell_t, \varepsilon_t \tau_t\right) &= u\left(\ell_t, \varepsilon_t \tau_t\right) + \upsilon\left(c_t, x_{t+1}\right), && (32)\\
u\left(\ell_t, \varepsilon_t \tau_t\right) &= \ell_t + \varepsilon_t \tau_t - \frac{1}{2}\left[\ell_t^2 + 2\gamma \ell_t \varepsilon_t \tau_t + \left(\varepsilon_t \tau_t\right)^2\right] && (33)\\
\upsilon\left(c_t, x_{t+1}\right) &= \phi \ln c_t + \theta \ln x_{t+1},\ 0 < \theta < \phi < 1,\ -1 \leq \gamma \leq 1 && (34)
\end{aligned}
$$

$$
H_t = B\left[\eta q_{t-1}^{\rho} + (1-\eta)\,\tau_{t-1}^{\rho}\right]^{1/\rho},\ 0 < \eta < 1,\ \rho > 0 \quad (35)
$$

$$
F_t = A K_t^{\alpha}\left[H_t L_t\right]^{1-\alpha},\ 0 < \alpha < 1 \quad (36)
$$

Variable	Meaning
A	TFP in goods production
B	TFP in human capital production
c_t	adult's own consumption
F_t	goods production function
H_t	worker's human capital/ labour productivity
I_t	investment in physical capital
K_t	stock of physical capital
L_t	time in paid work/ labour input
ℓ_t	leisure time
P_t	lump-sum transfer to a parent
q_t	child's consumption/ material input in human capital
R_t	lump-sum transfer to a retired
r_t	interest rate
s_t	savings
t_L	labour income tax rate
$U(\cdot)$	life-cycle utility of a parent
$u(\cdot)$	utility of leisure and parenting
$\upsilon(\cdot)$	utility of consumption
w_t	wage rate per hour per unit of labour productivity
x_{t+1}	consumption in retirement

Table 2: Variables and parameters

Variable	Meaning
α	capital share in goods production
β	degree of parental altruism
γ	substitutability between leisure and parenting
δ	depreciation rate of physical capital
ε	strength of preference for parenting
ε^*	benchmark preference for parenting
η	share of material input in human capital
θ	weight of consumption in retirement
λ	Lagrange multiplier
μ	parenting preference adjustment rate
π_t	period profit
ρ	substitutability between time and material input in human capital
τ_t	parenting time/ time input in human capital
ϕ	weight of consumption in working age
φ	weight of average parenting time in preference formation
ω	share of child benefit in total transfer

Table 3: Variables and parameters

Derivatives

$$\frac{\partial U_t}{\partial \ell_t} = \frac{\partial u_t}{\partial \ell_t} = 1 - \ell_t - \gamma \varepsilon_t \tau_t \tag{37}$$

$$\frac{\partial U_t}{\partial \tau_t} = \frac{\partial u_t}{\partial \tau_t} = \varepsilon_t \left[1 - \gamma \ell_t - \varepsilon_t \tau_t\right] \tag{38}$$

$$\frac{\partial U_t}{\partial c_t} = \frac{\partial \upsilon_t}{\partial c_t} = \phi c_t^{-1} \tag{39}$$

$$\frac{\partial U_t}{\partial x_{t+1}} = \frac{\partial \upsilon_t}{\partial x_{t+1}} = \theta x_{t+1}^{-1} \tag{40}$$

$$\frac{\partial H_{t+1}}{\partial q_t} = \frac{H_{t+1}}{q_t} \frac{\eta q_t^{\rho}}{\eta q_t^{\rho} + (1-\eta)\tau_t^{\rho}} \tag{41}$$

$$\frac{\partial H_{t+1}}{\partial \tau_t} = \frac{H_{t+1}}{\tau_t} \frac{(1-\eta)\tau_t^{\rho}}{\eta q_t^{\rho} + (1-\eta)\tau_t^{\rho}} \tag{42}$$

$$\frac{\partial F}{\partial K_t} = \alpha A K_t^{\alpha-1} \left(H_t L_t\right)^{1-\alpha} \tag{43}$$

$$\frac{\partial F}{\partial L_t} = H_t \left(1-\alpha\right) A K_t^{\alpha} \left(H_t L_t\right)^{-\alpha} \tag{44}$$

7.2 Steady state

Rewriting equations (15) – (20) in the paper for the steady state we have

$$r = \alpha A K^{\alpha-1} \left(HL\right)^{1-\alpha} \tag{45}$$

$$w = \left(1-\alpha\right) A K^{\alpha} \left(HL\right)^{-\alpha} \tag{46}$$

$$\frac{\partial u}{\partial \ell} = \left[1 - t_L\right] w H \left[1 + r\right] \frac{\theta}{x} \tag{47}$$

$$\frac{\partial H}{\partial \tau} / \frac{\partial H}{\partial q} = \left[1 - t_L\right] w H \left[1 - \frac{\partial u}{\partial \tau} / \frac{\partial u}{\partial \ell}\right] \tag{48}$$

$$\frac{1}{\beta} = \left[1 - t_L\right] w L \frac{\partial H}{\partial q} \tag{49}$$

$$c = \frac{\phi}{\theta} \frac{x}{\left[1 + r\right]} \tag{50}$$

$$\left[1 + r\right] \frac{\partial \upsilon}{\partial x} = \lambda \tag{51}$$

$$\left[1 - t_L\right] w H L + \left[P - \frac{\phi}{\theta} \frac{R}{1+r}\right] = q + \frac{\phi + \theta}{\theta} \delta K \tag{52}$$

In addition, from the private and public resource constraints it follows that

$$\delta K = \frac{x-R}{1+r} \tag{53}$$

$$P + R = t_L wHL \tag{54}$$

$$P = \omega t_L wHL;\ R = (1-\omega)\, t_L wHL \tag{55}$$

Now we eliminate all variables apart from L and τ. First, substitute (53) and (46) into (47) and rearrange to obtain

$$\frac{K}{HL} = \left[[1-t_L]\,(1-\alpha)\,A\frac{\theta}{\delta}\right]^{1/(1-\alpha)} \left[L\frac{\partial u}{\partial \ell}\right]^{-1/(1-\alpha)} \tag{56}$$

Use this in (46):

$$w = \left[(1-\alpha)\,A\left[[1-t_L]\,\frac{\theta}{\delta}\right]^{\alpha}\right]^{1/(1-\alpha)} \left[\phi L\frac{\partial u}{\partial \ell}\right]^{-\alpha/(1-\alpha)} \tag{57}$$

Next, use (53), (56), and (57) in (52) and rearrange to obtain

$$\frac{q}{H} = [1-t_L]\,wL\left[1-(\phi+\theta)\left[L\frac{\partial u}{\partial \ell}\right]^{-1}\frac{x-R}{x} + \frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]\,wHL}\right] \tag{58}$$

and, further,

$$\begin{aligned}\frac{q}{H} &= \left[(1-\alpha)\,[1-t_L]\,A\left[\frac{\theta}{\delta}\right]^{\alpha}\right]^{1/(1-\alpha)} L^{-\alpha/(1-\alpha)} \\ &\times\left[L\frac{\partial u}{\partial \ell}\left[1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]\,wHL}\right]-(\phi+\theta)\,\frac{x-R}{x}\right]\left[\frac{\partial u}{\partial \ell}\right]^{-1/(1-\alpha)}\end{aligned} \tag{59}$$

Now use (49) and (41) in (52):

$$\frac{\phi+\theta}{\theta}\delta\frac{K}{[1-t_L]\,wHL} = 1 + \frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]\,wHL} - \beta\frac{\eta q^{\rho}}{\eta q^{\rho}+(1-\eta)\,\tau^{\rho}} \tag{60}$$

Use (60) in (47) and in (53) to obtain

$$\frac{x}{[1+r]} = [1-t_L]\,wH\frac{\theta}{\frac{\partial u}{\partial \ell}} \tag{61}$$

$$\frac{\delta K}{[1-t_L]\,wH\theta} = \frac{1}{\frac{\partial u}{\partial \ell}}\frac{x-R}{x} \tag{62}$$

Use (60) in (62) to rewrite the latter as

$$\frac{L\frac{\partial u}{\partial \ell}\left[1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}\right]-[\phi+\theta]\,\frac{x-R}{x}}{\beta L\frac{\partial u}{\partial \ell}} = \frac{\eta q^{\rho}}{\eta q^{\rho}+(1-\eta)\,\tau^{\rho}}, \tag{63}$$

and, taking into account (35), this becomes

$$\frac{L\frac{\partial u}{\partial \ell}\left[1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}\right]-[\phi+\theta]\frac{x-R}{x}}{\beta L\frac{\partial u}{\partial \ell}}=\left[\frac{q}{H}\right]^{\rho}\eta B^{\rho} \tag{64}$$

Finally, use (59) to rewrite (64) as

$$\begin{aligned}&\left[L\frac{\partial u}{\partial \ell}\left[1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}\right]-[\phi+\theta]\frac{x-R}{x}\right]^{1-\rho}\\ =\;&\beta\eta B^{\rho}\left[(1-\alpha)[1-t_L]A\left[\frac{\theta}{\delta}\right]^{\alpha}\right]^{\rho/(1-\alpha)}L^{1-\alpha\rho/(1-\alpha)}\left[\frac{\partial u}{\partial \ell}\right]^{1-\rho/(1-\alpha)}\end{aligned} \tag{65}$$

Let

$$\xi_0\equiv\beta\eta B^{\rho}\left[(1-\alpha)[1-t_L]A\left[\frac{\theta}{\delta}\right]^{\alpha}\right]^{\rho/(1-\alpha)}, \tag{66}$$

then, using (37) in (65) we get

$$\begin{aligned}&\left[L[L+\tau[1-\gamma\varepsilon]]\left[1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}\right]-[\phi+\theta]\frac{x-R}{x}\right]^{1-\rho}\\ =\;&\xi_0 L^{1-\alpha\rho/(1-\alpha)}[L+\tau[1-\gamma\varepsilon]]^{1-\rho/(1-\alpha)}\end{aligned} \tag{67}$$

This is the first equation relating L and τ. To derive the second equation start with (48) and (49) and use (41) and (42) to obtain

$$\frac{1-\eta}{\eta}\left[\frac{q}{\tau}\right]^{-\rho}=[1-t_L]\frac{wH}{q}\tau\left[1-\frac{\partial u}{\partial \tau}/\frac{\partial u}{\partial \ell}\right] \tag{68}$$

$$\frac{1-\eta}{\eta}\left[\frac{q}{\tau}\right]^{-\rho}=\beta[1-t_L]wL\frac{H}{q}-1 \tag{69}$$

Equations (68) and (69) together imply

$$\left[\beta L-\tau\left[1-\frac{\partial u}{\partial \tau}/\frac{\partial u}{\partial \ell}\right]\right]=\frac{q}{wH}[1-t_L] \tag{70}$$

Substitute this into (58):

$$\frac{q}{wH}[1-t_L]=L\left[1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}-(\phi+\theta)\frac{x-R}{x}\left[L\frac{\partial u}{\partial \ell}\right]^{-1}\right] \tag{71}$$

Next, use (71) and (37)-(38) in (70) and collect the terms to obtain the second equation relating L and τ:

$$\begin{aligned}0\;=\;&\left(1+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}-\beta\right)L^2+\left(2+\frac{P-\frac{\phi}{\theta}\frac{R}{1+r}}{[1-t_L]wHL}-\beta\right)[1-\gamma\varepsilon]L\tau\\ &+\left[1-2\gamma\varepsilon+\varepsilon^2\right]\tau^2-[1-\gamma]\varepsilon\tau-(\phi+\theta)\frac{x-R}{x}\end{aligned} \tag{72}$$

Using (55), equations (67) and (72) can be written as

$$\begin{aligned} 0 &= \left[L\left[L+\tau\left[1-\gamma\varepsilon\right]\right]\left[1+\frac{\omega t_L-\frac{\phi}{\theta}\frac{(1-\omega)t_L}{1+r}}{1-t_L}\right]-\left[\phi+\theta\right]\frac{x-R}{x}\right]^{1-\rho} \\ &\quad -\xi_0 L^{1-\alpha\rho/(1-\alpha)}\left[L+\left[1-\gamma\varepsilon\right]\tau\right]^{1-\rho/(1-\alpha)} \qquad (73a) \\ 0 &= \left(1+\frac{\omega t_L-\frac{\phi}{\theta}\frac{(1-\omega)t_L}{1+r}}{1-t_L}-\beta\right)L^2+\left(2+\frac{\omega t_L-\frac{\phi}{\theta}\frac{(1-\omega)t_L}{1+r}}{1-t_L}-\beta\right)\left[1-\gamma\varepsilon\right]L\tau \\ &\quad +\left[1-2\gamma\varepsilon+\varepsilon^2\right]\tau^2-\left[1-\gamma\right]\varepsilon\tau-\left(\phi+\theta\right)\frac{x-R}{x} \qquad (73b) \end{aligned}$$

It remains to express r and $\frac{x-R}{x}$ in terms of L and τ. Using (56) along with (37) in (45) gives

$$r=\frac{\alpha}{1-\alpha}\frac{\delta}{\theta\left[1-t_L\right]}L\left[L+\tau\left[1-\gamma\varepsilon\right]\right].$$

Using (45), (46), (53), and (55), it is easy to obtain

$$\frac{x}{x-R}=1+t_L\frac{1-\omega}{\delta\frac{\alpha}{1-\alpha}\frac{1+r}{r}}.$$

Finally, the system of equations describing the steady-state equilibrium, can be written as

$$\begin{aligned} 0 &= \left[L\left[L+\tau\left[1-\gamma\varepsilon\right]\right]\left[1+\xi_1\right]-\frac{\phi+\theta}{\xi_2}\right]^{1-\rho}-\xi_0 L^{1-\alpha\rho/(1-\alpha)}\left[L+\left[1-\gamma\varepsilon\right]\tau\right]^{1-\rho/(1-\alpha)} \\ 0 &= \left(1+\xi_1-\beta\right)L^2+\left(2+\xi_1-\beta\right)\left[1-\gamma\varepsilon\right]L\tau+\left[1-2\gamma\varepsilon+\varepsilon^2\right]\tau^2-\left[1-\gamma\right]\varepsilon\tau-\frac{\phi+\theta}{\xi_2} \end{aligned}$$

where

$$\begin{aligned} \xi_0 &\equiv \beta\eta B^{\rho}\left[\left(1-\alpha\right)\left[1-t_L\right]A\left[\frac{\theta}{\delta}\right]^{\alpha}\right]^{\rho/(1-\alpha)} \\ \xi_1 &\equiv \frac{t_L}{1-t_L}\left[\omega-\frac{\phi}{\theta}\frac{1-\omega}{1+r}\right] \\ \xi_2 &\equiv 1+t_L\frac{1-\omega}{\delta\frac{\alpha}{1-\alpha}\frac{1+r}{r}} \\ r &= \frac{\alpha}{1-\alpha}\frac{\delta}{\theta\left[1-t_L\right]}L\left[L+\tau\left[1-\gamma\varepsilon\right]\right] \\ \varepsilon &= \varepsilon^*+\frac{\varphi}{\mu}\tau \end{aligned}$$