# Labor Income Taxation, Human Capital and Growth: The Role of Child Care

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## Abstract

This paper studies the implications of introducing child care in the human capital production function when assessing the effects of labor income taxation on growth. We develop an OLG model where formal schooling and child care enter the human capital production function as complements and we compare it with a model where only formal schooling matters for skill formation. Using a numerical analysis we find that, depending on the quality of child care services relative to parental care, the omission of child care from the technology of skills' formation can significantly bias the results related to the effects of labor income taxation on growth.


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Keywords: taxation, growth, human capital production function, child care, labor supply.

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## 1 Introduction

This paper studies the implications of introducing child care in the human capital production function for the assessment of the effects of labor income taxation on growth.

Recent literature focuses on the impact of taxation on the allocation of time between market labor, leisure and home production and it concludes that the cross-country differences in labor income taxation contribute to explain the cross-country differences in time allocation (see for instance Rogerson 2007 and Ragan 2006), with leisure and home production being, ceteris paribus, higher in countries where taxation is higher. Child care is among the home produced goods.

Differently from the existing literature which views child care only as a consumption good, we here model it not only as such but also as an input which enters the human capital production function. In doing so, we follow the received literature on the role of early environments on child development. The issue has been widely analyzed, especially in the psychology and sociology literature. Economists have more recently recognized the importance of parental time and child care on skills' acquisition (see Bernal 2008 for a review of the most recent contributions).

We develop a three-period OLG growth model where formal schooling and child care enter the production function of human capital as complements. Child care depends on the time that parents dedicate to child rearing and on the expenditure on goods and services which may impinge on the child development (e.g books or toys, day care centers' services, pre-school programs, baby-sitting). We compare a model where child care does not affect child development and a model where it does. While in the former set-up labor income taxation affects human capital accumulation only through the decision to invest in formal schooling, in the second framework, it also influences both directly and indirectly the growth rate through the change in the time parents devote to child care and the variation in the amount of child care expenditure. The direct effect goes through the impact of the change in child care on human capital, for a given level of formal schooling; the indirect effect passes through the complementarity between formal schooling and child care in the process of skills' formation. These are the new channels identified by the paper through which taxation has an impact on growth.

To explore these new channels and quantitatively assess their relevance we perform a numerical analysis of the model. When taxes are reduced, the net wage goes up inducing people to work more and dedicate less time to child care; this reduction in parental care may be compensated by an increase in the amount of child care expenditure. The overall impact of a cut in the tax rate on the formation of children's abilities depends on the elasticity of substitution between parental time and expenditure in the production of child care. If this elasticity is low, the rate of transmission of skills during childhood is weakened and the growth rate rises less than in a model where child care does not affect human capital accumulation. The opposite holds if this elasticity is high. We find that, quantitatively, the omission of child care from the technology of skills' formation can significantly bias the results related to the effects of taxation on growth: when parental care and child care services are hardly substitutable, the elasticity of the growth rate to labor income taxation is six times higher in a model which ignores the role played by child care in child development.

The elasticity of substitution between parental time and child care expenditure can be interpreted as an indicator of the quality of child care services relative to parental care. Thus, from a policy-oriented perspective, our results show that the cuts in labor income taxation have a strong impact on labor force participation and growth only when high quality non-parental care is available. We will elaborate more on this point in the conclusions.

The paper is organized as follows. In Section 2 we provide some evidence supporting the main mechanisms at work in our framework. In Section 3 we describe the building blocks of the model, we derive the first order conditions for consumers and firms and we define the intertemporal equilibrium and the balanced growth path. In Section 4 we perform a numerical analysis of the effects of taxation, comparing a model where child care matters for the process of skills' formation with a model where it does not. Section 5 concludes. The Appendix presents a sensitivity analysis on some of the parameters of the model.

## 2 Empirical evidence

Starting from the seminal work of Prescott (2004), recent literature (e.g. Rogerson 2007, Ragan 2006, Ohanian, Raffo, and Rogerson 2007) identifies a causal relationship between taxation and the allocation of time between market work, leisure and home production. It has been shown that, ceteris paribus, lower taxes deliver an increase in market work and a reduction in leisure and in the time devoted to home production.[1] For the purpose of our paper, one needs

[1]Taxes are one of the key factors which explain the cross-country differences in time allocation. To explain the time allocation in Scandinavian countries, the types of expenditures which are financed by higher taxation

to check that the increase in market work goes with a reduction in the time dedicated to one specific home-produced good, that is child care. Indeed, there are two main mechanisms at work in our paper: the existence of a trade-off between time devoted to market work and time devoted to child care and the impact of child care arrangements on human capital development.

To support the view that changes in market work also affect time dedicated to child care, we analyze data on time use taken from HETUS (Harmonised European Time Use Survey). We consider 9 countries (Belgium, Finland, France, Germany, Italy, Norway, Spain, Sweden and UK) and look at the sample of married or cohabiting individuals with the youngest dependent child below 6. We look for a measure of child care provided by parents: to this end, we select the activities recorded as "Physical care and supervision of child" and "Teaching, reading and talking with child" and coded as primary activities; we then add secondary child care.[2] This is a relatively narrow notion of child care as it does not include the time that parents spend not engaged in explicit child-related activities, but still in the presence of the children. We think that the narrow notion of child care we use better represents deliberate time devoted to kids, which is the choice variable in our model.

In Figure 1 we look at the percentages of those reporting any time in either primary or secondary child care and in Figure 2 we plot the minutes they devote to these activities. We distinguish between working and non-working individuals[3] and find that, in all countries, non working individuals have higher participation rates to the above mentioned activities and dedicate them more time.[4] We have also checked that this holds even when controlling for the number of children. These correlations suggests that there is a trade-off between market work and parental time devoted to child care.

Cawley and Liu (2007), using ATUS (American Time Use Survey) data, provide evidence of the existence of a causal relationship between maternal employment and time devoted to

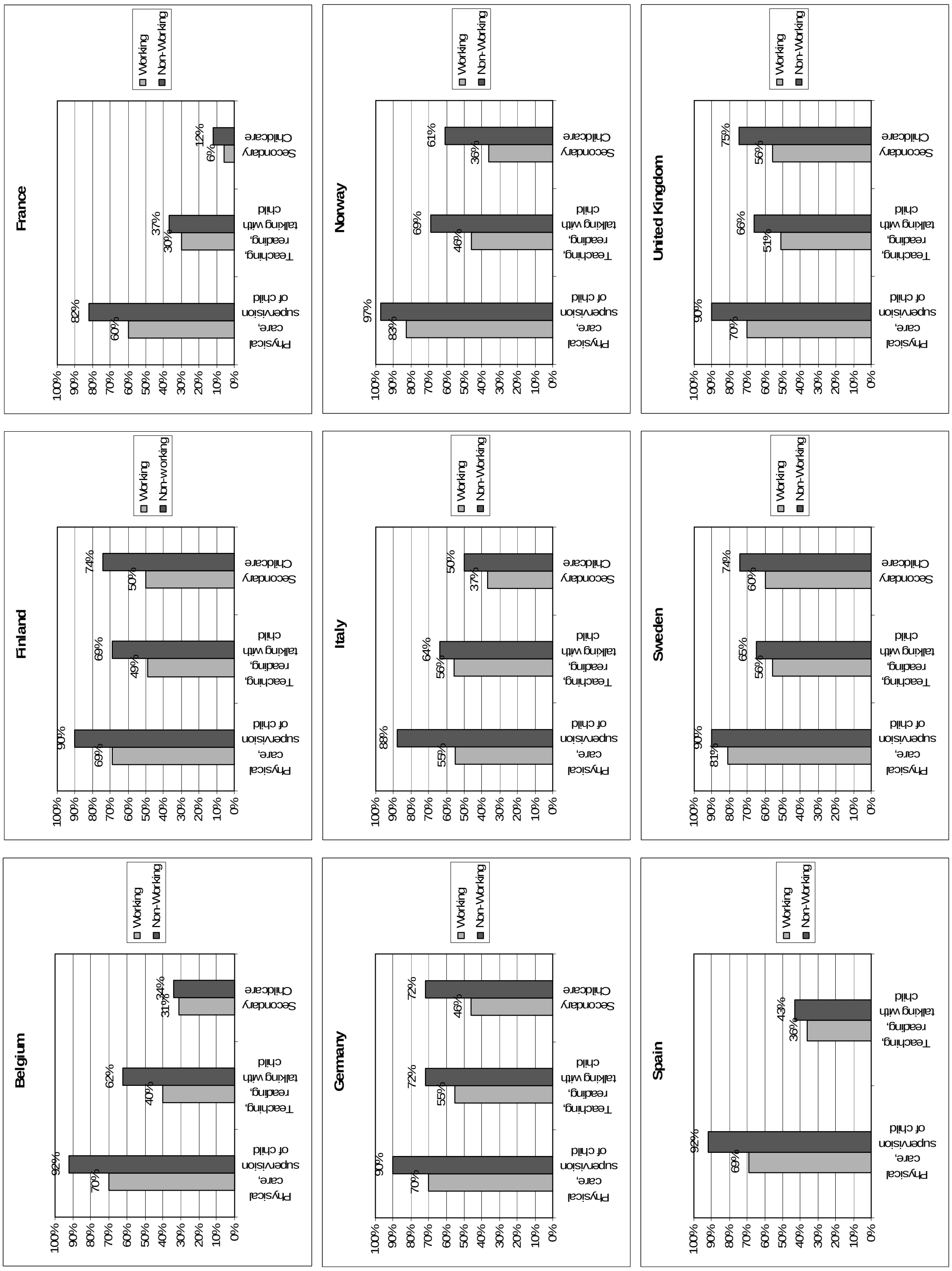
should also be considered.

[2]In HETUS, people are required to report both the main/primary activity they are involved in ("What did you do?") and the parallel/secondary activity they are doing ("Did you do anything else? If so, what?")

[3]Working parents include the categories "Employed full time" and "Employed part time"; non-working parents include the following categories: "On leave", "Unemployed", "Fulfilling domestic tasks", "On retirement".

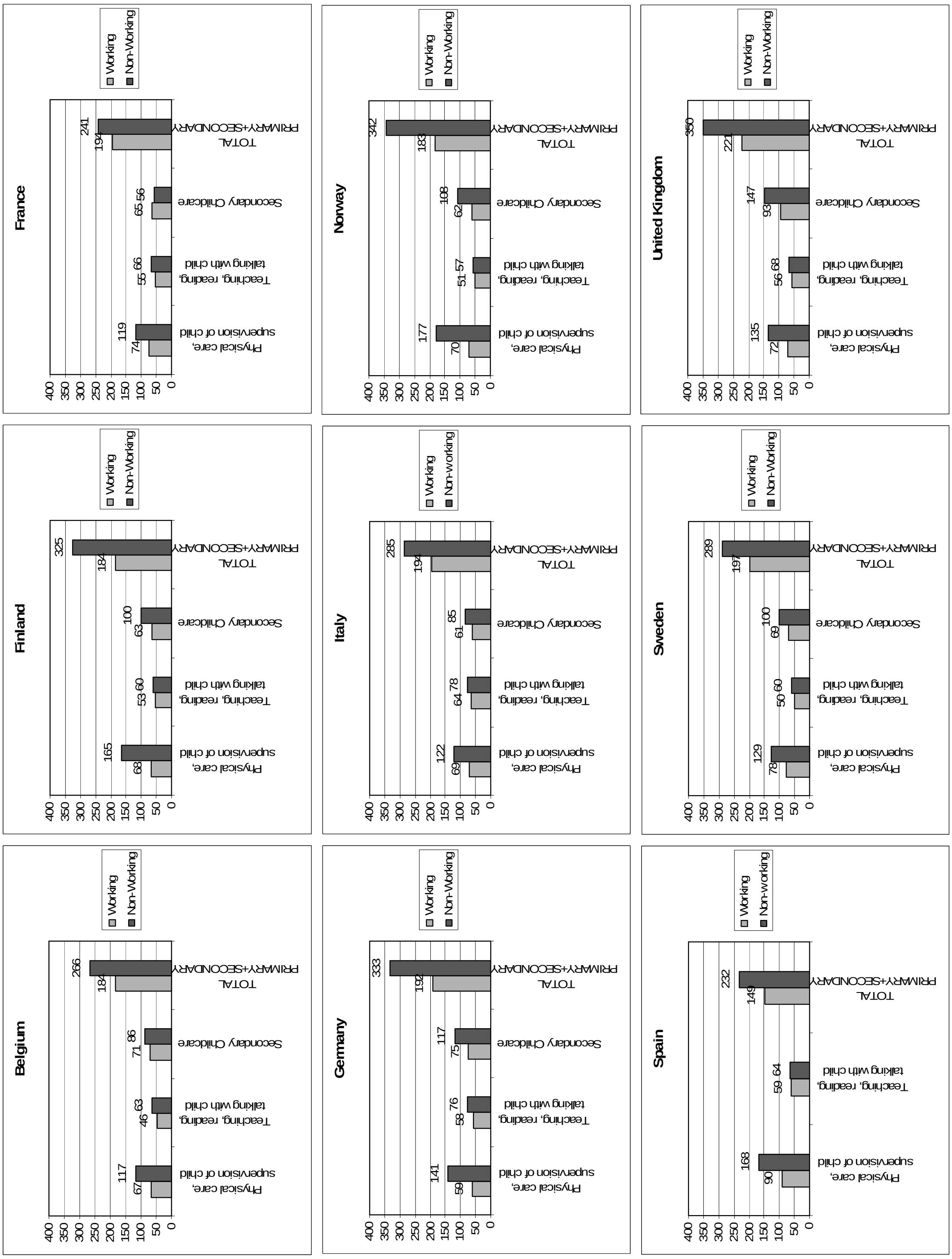
[4]The only partial exception concerns secondary child care in France. As we can see in Figure 2, average time devoted to this activity - conditional on participation - is slightly higher for working individuals. However notice that, since non-working people participate more in secondary child care, the overall average time devoted to this activity (given by the participation rate times minutes dedicated to the activity by those participating) is still higher for non-working parents.

Figure 1: Percentage of individuals reporting any time on primary and secondary childcare activities




Year considered: **Belgium** -2005-; **Finland** – 1999/ 2000-; **France** -1998/1999-; **Germany** – 2000/2001 -; **Italy** – 2002/ 2003 -; **Norway** 2000/2001; **Spain** – 2002/2003 - Sec. Childcare: Missing Value; **Sweden** – 2000/ 2001-; **UK** -2000/ 2001-.
“Primary activities”= “Physical care, Supervision of child” and “Teaching, reading, talking with child”

Figure 2: Number of minutes (per day) spent on primary and secondary childcare activities

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children. They control for various characteristics of mothers (e.g. education, race, marital status, age, number of children, age of the youngest children, whether the spouse - if any - is working or not) and estimate models with instrumental variables to deal with possible endogeneity problems: their result is that employed women spend significantly less time reading to their children, helping them with homework, and in educational activities in general. They interpret these findings as offering plausible mechanisms for the negative association -suggested by part of the literature- between maternal employment and child cognitive development.

Indeed, the family plays an important role in shaping the early environments in which children grow up. The importance of parental time vs. other types of child care in producing children abilities is analyzed in the empirical literature. The earlier contributions - as surveyed for instance by Ruhm (2004) - reach mixed conclusions. Some more recent studies tend to identify a negative impact of maternal employment on child care. Baker, Gruber, and Milligan (2005) for example, using Canadian data from the National Longitudinal Survey of Children and Youth (NLSCY), find that the increase in maternal employment following the introduction of universal child care in Quebec at the end of the Nineties made children worse off in a variety of behavioral and health-related dimensions. Other papers use US data from the National Longitudinal Survey of Youth (NLSY): Baum (2003) shows that maternal work in the first year of a child's life has detrimental effects on his cognitive skills. The analysis of Ruhm (2004) documents a negative relationship between maternal employment and child development, which is stronger for the reading and mathematics achievement of five- and six-year-olds than for the more commonly examined verbal ability of three- and four-year-olds. Bernal (2008) and Bernal and Keane (2007, 2008) also find that, on average, the substitution of maternal time with other child care sources produces negative and rather sizable effects on children skills. However, the last two papers show that this result masks some differences across types of child care and maternal education. Only informal care leads to significant reductions in child achievement; formal care (i.e. center-based care and preschool) does not have an adverse effect on cognitive outcomes and may have positive effects on children of poorly educated mothers. In other terms, the counterfactual to the absence of maternal care and the group under investigation matter in determining the results. This is documented also in Heckman and Masterov (2007) who review the evidence supporting the idea that high quality preschool centers available to disadvantaged children on a voluntary basis, coupled with home visitation programs, are highly effective in promoting achievement for disadvantaged children.

Whatever the precise sign of the effects identified, the conclusion which matters most for our investigation are that not only genetics but also parental choices in terms of time allocation and purchase of services affect the children's process of skill formation; moreover, that the quality of non-parental care plays a role in determining the children's outcomes. Similar conclusions can also be drawn looking at the review of the available evidence presented in OECD (2007).

Finally, we remark that what happens early in life affects the entire individual's skill formation process. This is described by recent literature (see Cuhna et al. 2005 for a review) as a dynamic process, characterized by strong complementarities between its different phases. As there are critical and sensitive periods for the development of both cognitive and non-cognitive abilities, later remediation for early deficits in the formation of some important abilities is difficult and costly. Some evidence suggests for example that the IQ can be affected by the environment in which the children live until the age of 10, but not later. Early investments not only have a direct impact on the level of human capital of an individual. As there is complementarity between investments at different stages, they make further investments more productive (skill begets skill). Carneiro and Heckman (2002, 2003), for instance, suggest that the most important factor explaining the positive relation between income and college enrollment in the US is not related to short term liquidity constraints that poor individuals may face, but to the fact that they lived in early environments which were unable to form the cognitive and non-cognitive abilities required for success in school. This complementarity between formal schooling and skills acquired during childhood is also documented in Leibowitz (2003)[5] and it is another key ingredient in our modeling strategy.

# 3 The model

We develop an OLG model with intragenerational homogeneity and endogenous growth driven by human capital accumulation. The model is set up in discrete time, from 0 to infinity. Agents have perfect foresight on future variables. They live for three periods and they have one child in the second period of life; the population growth rate is zero and fertility is exogenous; the size of each generation is normalized to 1.

Our formalization of the allocation of time and resources - whose details are presented in Section 3.1 - is quite standard and it has been for example used by Rogerson (2007) and Ragan

[5] See also the references quoted therein.

(2006) to discuss the effect of taxation on the allocation of time between labor, leisure and home production; the home produced good is interpreted as child care provided by parents through their own time and through the purchase of goods and services (e.g books or toys, day care centers' services, pre-school programs, baby-sitting).

The novelty of our model relies in the technology of human capital accumulation, which is described in Section 3.2: following the evidence reported in the previous Section, we explore the possibility that human capital not only depends on schooling but also on child care. In other terms, we study the consequences (as far as the growth impact of labor income taxation is concerned) of treating the home produced good not simply as a consumption good but also as a good which fosters human capital accumulation.

First order conditions for the optimization problems of the consumers and firms are presented in Section 3.3. Section 3.4 defines the intertemporal equilibrium and the balanced growth path.

### 3.1 Basic set-up

The time structure of individual choices is the following. In the first period of life, the child/the young receives child care and invests in formal schooling, borrowing on the capital market. In the second period of life the middle-aged/the parent pays back her loan and decides: how much to consume and save; how much time to devote to labor, leisure and child care; how much to spend on child care. In the third period of life, the old agent retires and consumes all her income.

In each period one physical good is produced using capital and labor measured in efficiency units. This good can be used for consumption, for investment in physical capital, for schooling expenditure and for child care expenditure.

*Preferences*

Preferences of an agent born at $t$ are described by the following utility function:

$$U_t = i_1 \log c^m_{t+1} + i_2 \frac{(z_{t+1})^\kappa}{\kappa} + i_3 \log x_{t+1} + \theta \log c^o_{t+2} \tag{1}$$

where $c^m_{t+1}$ and $c^o_{t+2}$ denote respectively consumption when middle-aged and old as no consumption takes place, by assumption, during childhood; $z_{t+1}$ stands for leisure time; $x_{t+1}$ indicates the home produced good; $i_j$ (with $j = 1, 2, 3$ and $\sum_j i_j = 1$) are positive parameters determining the weight of consumption, leisure and home production in the utility function;

$0 < \theta < 1$ is the subjective discount factor; $\kappa$ is a parameter $\leq 1$.

As we said, we interpret the home produced good $x_{t+1}$ as child care.

*Child care*

Child care $x_{t+1}$ is developed according to the following production function:

$$x_{t+1} = [\sigma(\varphi_{t+1})^{\nu} + (1-\sigma)(n_{t+1}h_{t+1})^{\nu}]^{\frac{1}{\nu}} \tag{2}$$

where $\varphi_{t+1}$ indicates child care expenditure; $n_{t+1}$ is the time parents devote to child rearing; $h_{t+1}$ is parents' human capital; $0 < \sigma < 1$ is a parameter determining the relative importance of child care expenditure and family time in the production of child care; $\nu \leq 1$ is a parameter governing the elasticity of substitution between $\varphi_{t+1}$ and $n_{t+1}$, $\zeta_{\nu} = \frac{1}{1-\nu}$.

As equation (2) suggests, child care outcomes depend on the productivity of the time devoted to it, that is, they depend on the human capital of the providers: parents with a high level of human capital $h_{t+1}$ can provide a given level of child care $x_{t+1}$ devoting to it a lower amount of time $n_{t+1}$ than low educated parents.

*Government's budget constraints*

The government budget constraint at $t+1$ is the following:

$$\tau_{t+1}w_{t+1}h_{t+1}l_{t+1} = T_{t+1} \tag{3}$$

where $\tau_{t+1}$ is the tax rate on labor income; $w_{t+1}$ is the wage; $l_{t+1}$ is the labor supply of the middle-aged; $T_{t+1}$ is the lump-sum transfer paid back to them. We consider $\tau_{t+1}$ as the exogenous policy variable, while $T_{t+1}$ is endogenously determined to guarantee the equilibrium in the budget constraint.

The assumption that tax proceeds are returned to the same individual as lump-sum transfers excludes intergenerational redistribution, it allows to isolate the effects of taxation from those of government expenditure and it is often present in the literature (e.g. King and Rebelo 1990, Stokey and Sergio 1995, Ihori 2001).

*Individual budget constraints*

A child born at time $t$ decides the amount of resources $e_t$ to devote to formal schooling. We assume that she borrows at the interest rate $r_{t+1}$ on the capital market and she pays back her loan in the second period.

The time and budget constraints are:

$$l_{t+1} + z_{t+1} + n_{t+1} = 1 \tag{4}$$

$$c^m_{t+1} = w_{t+1}h_{t+1}l_{t+1}(1-\tau_{t+1}) - s_{t+1} + T_{t+1} - \varphi_{t+1} - (1+r_{t+1})e_t \tag{5}$$

$$c^o_{t+2} = (1+r_{t+2})s_{t+1} \tag{6}$$

where $s_{t+1}$ are savings and where all the other variables have the same meaning as elucidated before.

*Production function*

Output $y_{t+1}$ is produced according to the following technology:

$$y_{t+1} = K^{\delta}_{t+1}L^{1-\delta}_{t+1} \tag{7}$$

where $K_{t+1}$ is the capital stock, $L_{t+1} = l_{t+1}h_{t+1}$ is the labor supply in efficiency units, and $0 < \delta < 1$ is the share of capital income in output.

### 3.2 Human capital production function

We consider two alternative human capital production functions. In the first one, human capital $h_{t+1}$ depends both on formal schooling $e_t$ and on child care $x_t$:

$$h_{t+1} = q\left[\lambda(e_t)^{\rho} + (1-\lambda)(x_t)^{\rho}\right]^{\frac{1}{\rho}} \tag{8}$$

where $q > 0$ is a scale parameter; $0 < \lambda < 1$ is a parameter determining the relative importance of formal schooling and child care in the production of human capital; $\rho \leq 1$ is a parameter governing the elasticity of substitution between formal schooling and child care $\zeta_{\rho} = \frac{1}{1-\rho}$. The above production function captures the idea that, depending on the degree of complementarity/substitutability between $e_t$ and $x_t$, early investments via child care can have permanent effects on educational outcomes and that early additions to a child's human capital may enhance the return of schooling investments.

In the second one, human capital depends, as it is usual, on schooling and on the human capital of the previous generation:

$$h_{t+1} = q\left[\lambda(e_t)^{\rho} + (1-\lambda)(h_t)^{\rho}\right]^{\frac{1}{\rho}} \tag{9}$$

The comparison between these two technologies allows us to assess the relevance of considering child care in the process of skills' formation, as far as the effects of taxation on growth are concerned.

Notice that early environments feature in both formalizations of the human capital production function: indeed, one may interpret the human capital of the previous generation in (9) as a measure of early environments. These, however, are not the result of child care choices, as it happens in (8).

### 3.3 First order conditions

*Consumer's optimization problem*

We solve the consumer optimization problem in two steps.

In the first step the representative individual born at $t$ chooses time $n_{t+1}$ and expenditure $\varphi_{t+1}$ in order to minimize the cost of producing a given amount of child care $x_{t+1}$. Such a cost is equal to:

$$\varphi_{t+1} + (1 - \tau_{t+1}) w_{t+1} h_{t+1} n_{t+1} \tag{10}$$

that is, expenditure on childcare plus forgone earnings due to the time spent in child care. Thus the agent minimizes equation (10) subject to the technology of child care production (2). This is a standard minimization problem which gives as a solution the following expenditure function:

$$C_{t+1}(x_{t+1}, \nu, \sigma, \tau_{t+1}) = \Gamma(\nu, \sigma, \tau_{t+1}) x_{t+1} \tag{11}$$

and conditional demand functions:

$$n_{t+1}(x_{t+1}, \nu, \sigma, \tau_{t+1}) = \frac{(1-\sigma)}{(1-\tau_{t+1})w_{t+1}}^{\frac{1}{1-\nu}} \Gamma(\nu, \sigma, \tau_{t+1}) \frac{x_{t+1}}{h_{t+1}} \tag{12}$$

$$\varphi_{t+1}(x_{t+1}, \nu, \sigma, \tau_{t+1}) = \sigma^{\frac{1}{1-\nu}} \Gamma(\nu, \sigma, \tau_{t+1}) x_{t+1} \tag{13}$$

where:

$$\Gamma(\nu, \sigma, \tau_{t+1}) = \left\{ \sigma^{-\frac{1}{(\nu-1)}} + (1-\sigma)^{-\frac{1}{(\nu-1)}} [(1-\tau_{t+1})w_{t+1}]^{\frac{\nu}{(\nu-1)}} \right\}^{\frac{\nu-1}{\nu}} \tag{14}$$

is the resource cost of producing one unit of child care. Since we are going to discuss the effects of taxation, it is useful for later reference to keep in mind that:

$$\frac{\partial \Gamma(\nu, \sigma, \tau_{t+1})}{\partial \tau_{t+1}} = -\left\{ \sigma^{-\frac{1}{(\nu-1)}} + (1-\sigma)^{-\frac{1}{(\nu-1)}} [(1-\tau_{t+1})w_{t+1}]^{\frac{\nu}{(\nu-1)}} \right\}^{-\frac{1}{\nu}} (1-\sigma)^{-\frac{1}{\nu-1}} w^{\frac{\nu}{\nu-1}} (1-\tau_{t+1})^{\frac{1}{\nu-1}} < 0 \tag{15}$$

that is, $\Gamma(\nu, \sigma, \tau_{t+1})$ is decreasing in $\tau_{t+1}$: indeed, foregone earnings due to time devoted to child rearing are higher when the tax rate is lower.

In the second step of the optimization problem, the agent chooses $e_t$, $x_{t+1}$, $l_{t+1}$, $s_{t+1}$, taking into account the results of the minimization problem solved above. Using the time constraint (4), the budget constraint of the adult (5) can be rewritten as:

$$c^m_{t+1} = (1 - \tau_{t+1}) w_{t+1} h_{t+1} (1 - z_{t+1} - n_{t+1}) - \varphi_{t+1} - s_{t+1} + T_{t+1} - (1 + r_{t+1}) e_t \tag{16}$$

which, using the expenditure function (11), becomes:

$$c^m_{t+1} = (1-\tau_{t+1})w_{t+1}h_{t+1}(1-z_{t+1}) - \Gamma(\nu,\sigma,\tau_{t+1})x_{t+1} - s_{t+1} + T_{t+1} - (1+r_{t+1})e_t \qquad (17)$$

Thus the agent maximizes the utility function (1) subject to the new budget constraint (17), the budget constraint (6), the time constraint (4) and the technology of skill formation (8) or (9).

Independently of the technology of skills' formation, the first order conditions for the choice of $x_{t+1}$, $l_{t+1}$, $s_{t+1}$ are:

$$s_{t+1} : i_1 \frac{1}{c^m_{t+1}} = (1+r_{t+2})\theta \frac{1}{c^o_{t+2}} \qquad (18)$$

$$l_{t+1} : i_2(z_{t+1})^{\kappa-1} = i_1 \frac{1}{c^m_{t+1}}(1-\tau_{t+1})w_{t+1}h_{t+1} \qquad (19)$$

$$x_{t+1} : i_1 \frac{1}{c^m_{t+1}}\Gamma(\nu,\sigma,\tau_{t+1}) = i_3 \frac{1}{x_{t+1}} \qquad (20)$$

The first order conditions for saving and labor, respectively given by equations (18) and (19), are the usual ones. Equation (20) concerns the choice of the home produced good, i.e. child care. The right hand side is the marginal benefit of the home produced good $x_{t+1}$. The left hand side is its marginal cost: it is given by the amount of consumption an agents should give up in order to produce one unit of child care, i.e. $\Gamma(\nu,\sigma,\tau_{t+1})$, times the marginal utility of consumption, i.e. $i_1 \frac{1}{c^m_{t+1}}$.

When the human capital production function is given by equation (8), the choice of the investment in education $e_t$ is characterized by:

$$e_t : (1+r_{t+1}) = q(1-\tau_{t+1})w_{t+1}l_{t+1} \frac{[\lambda(e_t)^\rho + (1-\lambda)(x_t)^\rho]^{\frac{1-\rho}{\rho}}}{(e_t)^{1-\rho}} \qquad (21)$$

If skills are accumulated according to equation (9), the first order condition for the choice of $e_t$ is given by:

$$e_t : (1+r_{t+1}) = q(1-\tau_{t+1})w_{t+1}l_{t+1} \frac{[\lambda(e_t)^\rho + (1-\lambda)(h_t)^\rho]^{\frac{1-\rho}{\rho}}}{(e_t)^{1-\rho}} \qquad (22)$$

The left hand side of equations (21) and (22) is the cost of an additional unit of $e_t$ and it depends on the interest rate, since young agents borrow resources on the capital market to finance their investment in schooling. The right hand side is the marginal benefit of schooling which is the change in net labor income due to the increased human capital level.[6] Notice

[6]In deriving equations (21) and (22) we assume that agents invest in education to enhance their own productivity on the labor market. The fact that human capital of a generation is also relevant for the human capital of the next one is treated, as it is often done, as an externality.

that, differently from equation (22), in equation (21) child care choices affect the return from schooling: a higher value of child care increases, *ceteris paribus*, the return from investing in schooling. We take up this remark later when we discuss the effects of taxation on growth (see Section 4.2).

*Firm's optimization problem*

Full depreciation of capital is assumed. Profit maximizing behavior of the competitive firms implies that the interest rate is:

$$1 + r_{t+1} = \delta \left( \frac{K_{t+1}}{L_{t+1}} \right)^{\delta - 1} \tag{23}$$

and that the wage in efficiency units is:

$$w_{t+1} = (1 - \delta) \left( \frac{K_{t+1}}{L_{t+1}} \right)^{\delta} \tag{24}$$

which are the standard conditions.

### 3.4 Intertemporal equilibrium and balanced growth path

We here define the intertemporal equilibrium. We focus on the case of a small open economy, in which the interest rate is exogenously fixed at the world level and it is assumed to be constant over time; as a consequence, the wage rate, according to the firm's first order conditions (23) and (24), is also constant.

Taking as given the initial level of savings $s_{-1}$ and of human capital $h_0$, the sequence of the exogenous policy parameter $\{\tau_t\}_0^\infty$, the interest rate $r$ and the wage $w$, an intertemporal equilibrium is defined by a sequence $\{e_t,c_t^m,s_t,c_t^o,l_t,\varphi_t,z_t,n_t,h_t,K_t,T_t\}_0^\infty$ that satisfies: the government budget constraint (3); the technology for the final output (7); the production function for human capital (8) or (9); the agent's maximization problem, characterized by equations (4), (6), (12) - (14), (17) - (20) and (21) or (22) and the clearing condition for the labor market.

Dividing the equations defining the intertemporal equilibrium by the level of human capital, it is possible to obtain their stationarized version. A balanced growth path (BGP) is, by definition, the steady state of such stationarized system and its existence requires the assumption that $\tau_t = \tau$ for all $t$. In other terms, a BGP is as an intertemporal equilibrium such that $\{l_t,z_t,n_t\}$ are constant and $\{e_t,c_t^m,s_t,c_t^o,\varphi_t,h_t,K_t,T_t\}$ grow at a constant common rate $g_{t+1} = g = \frac{h_{t+1}}{h_t}$.

If the human capital equation is (8), $g$ can be written as:

$$g = q \left[ \lambda (\widetilde{e})^\rho + (1 - \lambda)(\widetilde{x})^\rho \right]^{\frac{1}{\rho}} \tag{25}$$

where $\widetilde{e} = \frac{e_t}{h_t}$ and $\widetilde{x} = \frac{x_t}{h_t}$.

If the human capital equation is (9), $g$ is equal to:

$$g = q\left[\lambda(\widetilde{e})^{\rho} + (1-\lambda)\right]^{\frac{1}{\rho}} \tag{26}$$

In our analysis, we focus on the effects of a change in taxation on the balanced growth path.[7]

According to equation (25), the growth rate is a function of $\widetilde{e}$ and of $\widetilde{x}$. Intuitively, taxation affects, on the one hand, the returns to education because it alters both the net wage and the working time: this is the standard effect studied in the literature, which is also captured by equation (26). On the other hand, it changes the time parents devote to child care and it modifies the amount of child care expenditure: if the role played by child care in the process of skills' formation is recognized, as it is in (25), these changes in early environments have an impact on human capital accumulation.

To explore these effects and investigate how they combine and affect the growth rate, in the following Section we perform a numerical analysis of the model.

# 4 Numerical analysis

In this Section we perform a quantitative comparison, as far as the effects of taxation are concerned, of the two model economies described in Section 3, which only differ in the technology of skills' formation. In the first economy (henceforth: Model 1) human capital is produced according to the technology (9) and the growth rate can be written as in equation (26). The second model (henceforth: Model 2) is characterized by the human capital production function (8) and thus the growth rate is given by equation (25).

The purpose of such a comparison is to understand if and how the recognition of the role played by child care in the process of skills formation affects the growth impact of taxation.

## 4.1 Parameterization and Calibration

The first step is to assign a value to the parameters of the model.

We assume that each period has a length of 25 years. The world annual interest rate is set to 4.5%. The intertemporal discount factor $\theta$ is set to 0.37 (the quarterly discount factor

[7]Though the focus is not directly on individual utility and social welfare, we stress that in the long run the higher the growth rate, the higher the individual utility.

is 0.99). We choose $\delta = 0.29$, that is the share of capital income in national product amounts to 29% (see Bouzahzah, de la Croix, and Docquier 2002).

The parameter $q$ of the human capital production function is chosen in order to obtain an annual growth rate equal to 1.8%.

The parameter $\sigma$ in the production of child care is chosen to match a value for the ratio between child care expenditure and total consumption (i.e. the sum of consumption of the adult and of the old) equal to 1.5%, which is in the middle of the range of values reported by Ragan (2006).

We choose $i_j$ with $j = 1, 2, 3$ in order to generate a realistic allocation of time between labor, child care and leisure. For this purpose we consider average data coming from the Harmonized European Time Use Survey (HETUS).[8] Assuming, as it is usually done (e.g. Ragan 2006, Cardia and Ng 2003, Juster 1985), that non-personal time available for discretionary use amounts to 100 hours per week, we have: $l = 32\%$, $n = 6\%$ and $z = 62\%$. Two remarks are important in interpreting these data. First, child care is simply defined as the sum of the minutes registered as devoted to primary and secondary child care: this amount of time, as stressed in Section 2, is lower than the total time spent with children. Second, leisure is here defined as a residual category, that is, it is the time not spent either working or doing primary and secondary child care: as a consequence, it is not a measure of pure leisure as it also includes housework.

As far as the choice of $\lambda$ and $\tau$ is concerned, we use average data computed for the same set of countries considered for determining the allocation of time. In particular, the parameter $\lambda$ is set in order to match a ratio between expenditure on formal schooling and GDP equal to 5.7%, which is the average of the total (public plus private) expenditure on education. Though we do not have public education in the model, we consider the total expenditure on education and not just the private one since our government budget constraint (3) is consistent with perfect substitution between public and private expenditure. The policy parameter $\tau$ is chosen equal to 53%, which is the average of the marginal tax rates on labor income computed by Dhont and Heylen (2008) using OECD data.

Finally, we need to set $\nu$, $\rho$ and $\kappa$. The first two parameters respectively determine the

[8] The countries we consider are again: Belgium, Finland, France, Germany, Italy, Norway, Spain, Sweden and UK. Data refers to people in the age group 25-50, which correspond in our three period OLG model to people in their second period of life.

elasticity of substitution between child care expenditure and parental time $\zeta_\nu = \frac{1}{1-\nu}$ and the elasticity of substitution between formal schooling and child care $\zeta_\rho = \frac{1}{1-\rho}$; $\kappa$ is the parameter which appears in equation (1) for the utility of leisure.

As far $\nu$ is concerned, some estimates are available. Estimates coming both from aggregate data (McGrattan, Rogerson, and Wright 1997 and Chang and Schorfheide 2003) and from micro data (Rupert, Rogerson, and Wright 1995 and Aguiar and Hurst 2005) suggest a value in the range $[0.4, 0.6]$. However, these estimates refer to a large set of home produced goods. When the focus is on child care the estimates could be different. Moreover, notice that the parameter $\nu$ can be interpreted as the quality of child care services provided; it is not easy to measure precisely this quality, but there are some indications that it is quite different across countries (see the OECD Family data base). Though it is difficult to pin down a precise value for $\nu$, the above discussion suggests that reasonable values should be between 0 and 1. Thus we perform a sensitivity analysis in this range.

There are no well established estimates for $\rho$. However, there are reasons to think that the degree of substitutability between child care and formal schooling is quite low (see the references in Section 2). In standard macroeconomic models, which describe human capital accumulation using equation (9), the choice is usually $\rho = 0$, i.e. a Cobb-Douglas specification. We adopt this parametrization and, in the Appendix, we perform a sensitivity analysis exploring the effect of choosing lower values of $\rho$.

Finally, we choose $\kappa = -4$. The implied wage elasticity of the uncompensated labor supply obviously depends on $\nu$: when $\nu$ is between 0 and 0.4, it is equal to approximately 0.4. It goes to 1.8 when $\nu = 0.98$ (with intermediate values equal to: 0.5 when $\nu = 0.8$; 0.7 when $\nu = 0.9$; 1.2 when $\nu = 0.95$).[9] These values may appear high if compared with the microeconometric estimates: the meta analysis of Evers, De Mooij, and Van Vuren (2008) suggests a value for the wage elasticity of uncompensated labor supply equal to 0.1 for men and 0.5 for women. However, it has been stressed that macro and micro elasticities need not to be the same: the former can be much higher than the latter (Rogerson and Wallenius 2007, Chang and Kim 2006, Fiorito and Zanella 2008). Nonetheless, in the Appendix we argue that our findings are robust to the choice of lower values of $\kappa$.

[9] The wage elasticity of the uncompensated labor supply is defined as the percentage change in hours worked as a result of a one percent change in the *net wage rate* $(1-\tau)w$. It can be computed as $\frac{1-\tau}{\tau}\eta$ where $\eta$ is the elasticity of the uncompensated labor supply with respect to the *tax rate* $\tau$, which can be derived from Table 2 of Section 4.2.

Table 1: Parameterization and Calibration

| | | |
|---|---|---|
| Tax rate | $\tau$ | 53.3% |
| Share of capital income | $\delta$ | 29% |
| Discount factor | $\theta$ | 0.37 |
| Weights in the utility function | $i_j$ | chosen to match the allocation of time between labor (32%), time devoted to children (6%) and leisure (62%). |
| Weight of formal schooling | $\lambda$ | chosen to match a ratio between total expenditure on formal schooling and GDP equal to 5.7% |
| Weight of childcare expenditure | $\sigma$ | chosen to match a ratio between child care expenditures and consumption equal to 1.5% |
| Elasticity of substitution between child care expenditures and parental time | $\zeta_\nu = \frac{1}{1-\nu}$ | Sensitivity analysis in the range $0 \leq \nu < 1$ |
| Elasticity of substitution between formal schooling and early environments | $\zeta_\rho = \frac{1}{1-\rho}$ | $= 1$ ($\rho = 0$ i.e. Cobb-Douglas case) |
| Parameter of the utility of leisure | $-\frac{z^\kappa}{\kappa}$ | $\kappa = -4$ The implied wage elasticity of uncompensated labor supply goes from 0.41 to 1.77 (depending on the value of $\nu$) |

It is important to stress that the parameters $r$, $\theta$, $\delta$, $\tau$, $\nu$, $\rho$ and $\kappa$ are the same in the two economies we compare. On the other hand the values of $\sigma$, $\iota_j$ and $\lambda$, i.e. the calibrated parameters, may differ in Model 1 and 2 since they are chosen to match the target values described above: in other terms, we want to compare economies which differ in the technology of skills' formation but are observationally equivalent.

The assumptions underlying the numerical simulation are summarized in Table 1.

## 4.2 Simulation's results

We compute the effects of a 10% reduction in labor income taxation , i.e. a reduction of $\tau$ from 53% to 47.7%, both in Model 1 and in Model 2. The results are presented in Table 2, in which values relative to $\tau = 53\%$ are reported[10]. The $\widetilde{}$ denotes a stationarized variable.

We notice that the effects of taxation are the same in the two models for all the variables but for $g$ and $\widetilde{e}$, whose reactions to $\tau$ depend on the presence of child care in the process of

[10]In other terms, Table 2 reports the ratio between the value of a variable when $\tau = 47.7\%$ and when $\tau = 53\%$.

Table 2: Effects of a 10% reduction in the tax rate on labor income

| | $\nu = 0.0$ | | $\nu = 0.4$ | | $\nu = 0.8$ | | $\nu = 0.9$ | | $\nu = 0.95$ | | $\nu = 0.98$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| $g$ | 1.17 | 1.03 | 1.17 | 1.03 | 1.18 | 1.06 | 1.21 | 1.11 | 1.26 | 1.22 | 1.22 | 1.39 |
| $\widetilde{e}$ | 1.25 | 1.18 | 1.26 | 1.18 | 1.28 | 1.21 | 1.32 | 1.26 | 1.41 | 1.39 | 1.54 | 1.59 |
| $\widetilde{x}$ | 0.94 | | 0.94 | | 0.95 | | 0.96 | | 0.98 | | 1.03 | |
| $l$ | 1.05 | | 1.05 | | 1.06 | | 1.08 | | 1.13 | | 1.20 | |
| $n$ | 0.92 | | 0.91 | | 0.84 | | 0.71 | | 0.41 | | 0.03 | |
| $z$ | 0.98 | | 0.98 | | 0.98 | | 0.99 | | 0.99 | | 0.99 | |
| $\widetilde{\varphi}$ | 1.02 | | 1.09 | | 1.43 | | 2.06 | | 3.46 | | 5.43 | |
| $\widetilde{c}^m$ | 1.02 | | 1.03 | | 1.03 | | 1.03 | | 1.05 | | 1.07 | |
| $\Gamma(\nu, \sigma, \tau)$ | 1.09 | | 1.09 | | 1.09 | | 1.08 | | 1.06 | | 1.03 | |

skills' formation.

To discuss the main results of Table 2 and to provide the intuition behind them, we first focus on changes in $\widetilde{x}$. Then we turn to the explanation of the different results for $g$ and $\widetilde{e}$ that are obtained in Model 1 and in Model 2, i.e. when $\widetilde{x}$ is respectively omitted from and included in the human capital production function.

The mechanisms determining the changes of $\widetilde{x}$ can be intuitively grasped as follows. Dividing both sides of equation (20) by the level of human capital, it is possible to characterize the choice of $\widetilde{x}$ through the following stationarized version of the first order condition for child care:

$$i_1 \frac{1}{\widetilde{c}^m} \Gamma(\nu, \sigma, \tau) = i_3 \frac{1}{\widetilde{x}} \tag{27}$$

where $\widetilde{c}^m = \frac{c_t^m}{h_t}$. As it can be seen from equation (15), a decrease in the tax rate rises $\Gamma(\nu, \sigma, \tau)$, that is the amount of consumption an agent should give up in order to produce one unit of child care: indeed, foregone earnings due to time devoted to child rearing are now higher. However the evaluation of $\Gamma(\nu, \sigma, \tau)$ in terms of utility decreases, since the marginal utility of consumption goes down as $\widetilde{c}^m$ rises in our computational experiment.

In other terms, there are what we could call a substitution effect - passing through $\Gamma(\nu, \sigma, \tau)$ - and an income effect - passing through $\widetilde{c}^m$ - which go in opposite directions: the overall impact on $\widetilde{x}$ depends on the values of $\nu$. If it is very easy to substitute parental time with child care expenditure (i.e $\nu = 0.98$ in Table 2), $\widetilde{x}$ rises; when this substitution is more difficult, $\widetilde{x}$ decreases. This can be intuitively understood looking in Table 2 at how the changes in $\Gamma(\nu, \sigma, \tau)$ and $\widetilde{c}^m$ are affected by $\nu$. Indeed, the lower the substitutability between child care expenditure and parental time, the larger the increase in $\Gamma(\nu, \sigma, \tau)$ and the smaller the increase in $\widetilde{c}^m$.

The change in $\widetilde{x}$ is driven by adjustments in the inputs of child care, that is parental time and child care expenditure. In our simulation, parental care $n$ always decreases and child care expenditure as a share of human capital $\widetilde{\varphi} = \frac{\varphi_t}{h_t}$ always rises, with the former variation not compensating (more than compensating) the latter when $\widetilde{x}$ decreases (increases).

Once we have provided the intuition for the changes in $\widetilde{x}$, we focus on the different effect that taxation has on the growth rate and on the stationarized investment in formal schooling in Model 1 and 2.

In Model 1, the growth rate $g$ only depends on $\widetilde{e}$, whose choice is characterized by the following stationarized version of equation (22)(with $\rho = 0$):

$$(1 + r) = q(1 - \tau)wl\lambda \left(\frac{1}{\widetilde{e}}\right)^{1-\lambda} \tag{28}$$

Once the tax rate is reduced, the net wage $(1 - \tau)w$ and the labor supply $l$ rise, increasing the benefit from investing in formal schooling: this tends to induce a higher level of $\widetilde{e}$.

In Model 2, formal schooling is not the only way to produce skills: child care plays a role in the process of human capital accumulation. The changes in $\widetilde{x}$ discussed above affect both directly and indirectly the growth rate. The direct effect goes through the impact of the change in child care on human capital, for a given level of formal schooling: this can be immediately understood from equation (25). The indirect impact passes through the complementarity between formal schooling and child care, which implies that $\widetilde{e}$ is affected by a variation of $\widetilde{x}$, as it can be realized from the following stationarized version of the first order condition (21) (with $\rho = 0$):

$$(1 + r) = q(1 - \tau)wl\lambda \left(\frac{\widetilde{x}}{\widetilde{e}}\right)^{1-\lambda} \tag{29}$$

This indirect channel can be identified looking at the different impact that taxation has on $\widetilde{e}$ in Model 1 and 2 (see Table 2): in the case where $\widetilde{x}$ goes down, the change of $\widetilde{e}$ is lower in the latter model; the opposite holds when $\widetilde{x}$ rises.

These effects (both the direct and the indirect one) explain why, in Table 2, the growth rate rises more in Model 2 than in Model 1 when $\nu$ is very high: indeed, in such a case $\widetilde{x}$ rises. The opposite holds when $\nu$ is lower, since in this case $\widetilde{x}$ decreases.

Once we have explained the general qualitative patterns of the analysis, we focus on the quantitative findings. For low values of $\nu$, i.e. $\nu = 0$ and $\nu = 0.4$, the elasticity of the growth rate to labor income taxation is six times higher in Model 1 than in Model 2.[11] When $\nu$ rises, the ratio between the values of this elasticity in the two models tends to decrease. It is equal to: 3, when $\nu = 0.8$; 2, when $\nu = 0.9$; 1.2, when $\nu = 0.95$. When $\nu = 0.98$, this ratio is 0.6: as we have already said, in this case the effect of taxation is higher once child care is included in the human capital production function. Thus we can conclude that the omission of child care from the technology of skills' formation can significantly bias the results related to the effects of taxation on growth; the sign and the magnitude of this bias depend on $\nu$.

To correctly understand the results, it is important to remind that $\widetilde{x}$ is defined as $\frac{x_t}{h_t}$, i.e. the ratio between the skills received during childhood $x_t$ and the human capital of the previous generation $h_t$. In other terms, $\widetilde{x}$ can be interpreted in Model 2 as the rate of intergenerational transmission of skills in early environments. As a consequence, a reduction in $\widetilde{x}$ caused by a tax cut should be read as a decrease in the *rate of transmission* of skills during childhood and not necessarily as a reduction in their *absolute level* $x_t$, as long as $h_t$ rises. Actually, in our computational experiment, since the growth rate is higher when taxes are lower, we are sure that in the very long run the level of human capital will be high enough to guarantee that the skills received during childhood $x_t$ always increase after a cut in $\tau$, even when $\widetilde{x}$ goes down. Indeed, a highly educated generation transmitting to its children a low fraction of its own human capital can still provide its kids with a higher level of skills than a low educated generation transmitting a higher fraction of its given (lower) abilities.

We can thus summarize the main difference between the two models in the following way. In Model 1 the effect of early environments on the process of skills' formation is simply captured by the human capital of the previous generation which is automatically inherited by children. As a consequence, the rate of transmission of skills during childhood is constant and it does not depend on the tax rate. This is not true in the case of Model 2, in which human capital accumulation is affected by child care choices: in this situation the rate of transmission of skills $\widetilde{x}$ reacts to taxation and the sign and the magnitude of the change depend on the elasticity of substitution between parental time and child care.

As we remark in Section 4.1, this elasticity of substitution can be interpreted as a parameter reflecting the relative quality of available non parental care, which seems to be different across

[11] The elasticity of the growth rate to labor income taxation is defined as the percentage change in the growth rate as a result of a one percent change in the tax rate on labor income. The values of this elasticity can be immediately derived from the numbers presented in Table 2, subtracting 1 and then multiplying by 10.

countries. Relying on this observation, the next Section sets the analysis we have performed in the context of the current policy debate on the need to promote work-life balance policies.

## 5 Conclusions

The public debate is devoting increasing attention to the issue of the quality of child care services. This is justified by the need to reconcile in a satisfactory way work and family life, given the policy objective, shared by many countries, to increase (especially female) labor supply. Such an objective has been for example formalized by the EU countries in the so called Lisbon strategy, which fixed as a target an overall employment rate in excess of 70% and a female employment rate in excess of 60% by 2010. The tax policy is seen as one important means to achieve this goal.[12]

The quality of non-parental care is not only important to provide parents with a tool to combine effectively work and family life. It is also important as a key factor to avoid damages to and to promote the formation of children's abilities. In this perspective, quality standards of child care services should not simply cover health and safety checks, rules on staff certification requirements, and staff-to-child ratios, but they should also include child developmental goals (OECD 2006, 2007).

In the paper we show that the role played by (the quality of) child care in the process of skills' formation is also relevant from a macroeconomic point of view, being crucial in determining the long-run effect of taxation and how the increase in labor force participation affects economic performance, as measured by GDP growth. We find that the omission of child care from the technology of skills' formation can significantly bias the results related to the effects of labor income taxation on growth.

The analysis we have performed can be extended in several directions. The introduction of endogenous fertility, agents' heterogeneity and an explicit gender dimension, seem the most natural avenues to pursue. These extensions are left for future research.

[12]In this light one can read the proposal of gender-based taxation - recently put forward in Alesina, Ichino, and Karabarbounis (2007)- as a tool to increase female labor supply .

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## Appendix

In this Appendix we discuss the effects of choosing different values for two parameters of the model: $\rho$, which determines the elasticity of substitution between formal schooling and child care, and $\kappa$, which influences the wage elasticity of the uncompensated labor supply.

*Sensitivity analysis on the complementarity between formal schooling and child care*

The evidence presented in Section 2 suggests that the degree of substitutability between formal schooling and child care should be low. In Section 4.1 we choose $\rho = 0$, i.e. a Cobb-Douglas specification for the human capital production function. This choice is standard in growth models where human capital accumulation is described by equation (9) and it implies a sufficiently high degree of complementarity between formal schooling and child care. We have also explored the effects of choosing a higher complementarity, i.e. $\rho < 0$. The result of this sensitivity analysis are summarized in Table 3 which focuses on the effects of taxation on the growth rate $g$.

The qualitative patterns are the same as those discussed in Section 4.2. Comparing Table 3 with Table 2 we see that the difference between Model 1 and Model 2 is quantitatively even

Table 3: Effects on the growth rate $g$ of a 10% reduction in the tax rate on labor income ($\rho < 0$)

| | $\nu = 0.0$ | | $\nu = 0.4$ | | $\nu = 0.8$ | | $\nu = 0.9$ | | $\nu = 0.95$ | | $\nu = 0.98$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| $\rho = -0.1$ | 1.15 | 1.02 | 1.15 | 1.02 | 1.16 | 1.05 | 1.18 | 1.09 | 1.23 | 1.20 | 1.28 | 1.36 |
| $\rho = -0.2$ | 1.14 | 1.00 | 1.14 | 1.01 | 1.15 | 1.03 | 1.17 | 1.08 | 1.21 | 1.18 | 1.26 | 1.34 |
| $\rho = -0.3$ | 1.12 | 0.99 | 1.13 | 1.00 | 1.14 | 1.02 | 1.15 | 1.07 | 1.19 | 1.17 | 1.23 | 1.32 |

stronger (in particular for low values of $\nu$) when $\rho < 0$. The elasticity of the growth rate to labor income taxation may be 35 times higher in Model 1 than in Model 2 (this happens when $\nu = 0$ and $\rho = -0.2$). When the quality of non parental care is very low ($\nu = 0$) and the complementarity between formal schooling and child care is high ($\rho = -0.3$), the effect of a reduction of the tax rate is even (slightly) negative in Model 2.

The intuition behind these findings is that, when $\rho < 0$, the indirect effect played by child care in the process of skills' formation (see Section 4.2) is stronger.

*Sensitivity analysis on the wage elasticity of uncompensated labor supply*

In Section 4.1 we choose $\kappa = -4$. We have stressed that this value implies a wage elasticity of the uncompensated labor supply which can be considered high when compared to micro estimates. We justified our choice by taking into account that it has been shown that macro elasticities are likely to be higher than micro elasticities. Nonetheless, we here stress that lower values of $\kappa$ (which imply a lower wage elasticity of the uncompensated labor supply) do not weaken the argument presented in the paper: actually, our results are strengthened.

The basic idea can be grasped looking at equation (27): we have explained in the text that, following a cut in the tax rate, the change of $\widetilde{x}$ depends on a substitution effect related to the increase in $\Gamma(\nu, \sigma, \tau)$ and on an income effect due to $\widetilde{c}^m$. The size of the change in $\Gamma(\nu, \sigma, \tau)$ is unaffected by $\kappa$, as we can see from equation (15). On the other hand, the size of the increase in $\widetilde{c}^m$ could vary when $\kappa$ is reduced; our intuition is that it is lower, since the increase in the labor supply and thus in labor income is less strong.

To verify such a reasoning we have simulated the model with lower values of $\kappa$ ($\rho$ is set $= 0$ as in Section 4.2). Table 4 reports the results for $\kappa = -8$, focusing on $g$, $\widetilde{x}$ and $\widetilde{c}^m$.

Comparing Table 4 with Table 2 we see that, as expected, the increase in $\widetilde{c}^m$ is lower when

Table 4: Effects of a 10% reduction in the tax rate on labor income ($\kappa = -8$)

| | $\nu = 0.0$ | | $\nu = 0.4$ | | $\nu = 0.8$ | | $\nu = 0.9$ | | $\nu = 0.95$ | | $\nu = 0.98$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| $g$ | 1.16 | 0.99 | 1.16 | 1.00 | 1.17 | 1.03 | 1.20 | 1.08 | 1.25 | 1.19 | 1.32 | 1.38 |
| $\widetilde{x}$ | 0.93 | | 0.93 | | 0.94 | | 0.95 | | 0.98 | | 1.03 | |
| $\widetilde{c}^m$ | 1.01 | | 1.02 | | 1.02 | | 1.03 | | 1.04 | | 1.06 | |

$\kappa = -8$; as a consequence, for low values of $\nu$, the decrease in $\widetilde{x}$ is stronger and the difference in the growth impact of taxation between Model 1 and Model 2 is more sizable.[13] When $\nu = 0.4$, the growth rate in Model 2 is unaffected by the reduction of the tax rate, while in Model 1 it increases by 16%. When $\nu = 0$, the effect of a reduction of the tax rate in Model 2 is even (slightly) negative.

[13] The choice of $\kappa = -8$ implies that the wage elasticity of the uncompensated labor supply is equal to: 0.3 when $\nu = 0$ or $\nu = 0.4$; 0.4 when $\nu = 0.8$; 0.65 when $\nu = 0.9$; 1.1 when $\nu = 0.95$; 1.8 when $\nu = 0.98$. Notice that the effect that the choice of $\kappa$ has on the wage elasticity of the uncompensated labor supply tends to disappear when the elasticity of substitution between child care expenditure and parental time is high. This explains why the difference between the results in Table 4 and Table 2 is more sizable when $\nu$ is low.

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