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Public policies over the life cycle: a large scale OLG model for France, Italy and Sweden

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Abstract

The paper presents a large scale overlapping generation model with heterogeneous agents, where the family is the decision unit. We calibrate the model for three European countries – France, Italy and Sweden – which show marked differences in the design of some public programs. We examine the properties in terms of annual and lifetime redistribution of a number of tax-benefit programs, by studying the impact of removing from our model economies some or all of them. We find that whether one considers a life-cycle or an annual horizon, and whether behavioral responses are accounted for or not, has a large impact on the results. The model may provide useful insights for policy makers on which kind of reforms are more likely to achieve specific equity objectives.

Keywords: Redistribution, Fiscal policy, Computable OLG models.
JEL Classification: H2, H3.

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1 Introduction

Most of the public sector interventions in the economy are justified by redistributive goals. The set of tools employed to this end is typically large, including several tax and transfer programs with complex interactions among them, and, in some cases, potentially offsetting effects. These tools are usually targeted to annual incomes. However inequality in living standards is more appropriately captured by the distribution of lifetime income and it is known that measures of annual and lifetime incomes are remarkably different (Aaberge and Mogstad, 2012).

Due to such complexities, a full understanding of the redistributive impact of public sector intervention is hard to obtain both theoretically and empirically. Theoretical contributions typically focus on one program at the time, while the modelling of indirect effects on other programs is usually stylized. From the empirical perspective, addressing these questions is highly demanding in terms of data availability. In particular, longitudinal data are rarely sufficiently rich to allow an estimate of lifetime income redistribution.[1]

We propose a large scale overlapping generation (OLG) model with intra-generational heterogeneity[2] and with a comprehensive description of public sector intervention. In particular, we consider personal income tax, consumption tax, capital income tax, social contributions, pension benefits, health care, child benefit, subsidy to daycare, and income support. We model these policies for three European countries: France, Italy and Sweden. Ideally, one would like to compare the size of redistribution across countries which are as similar as possible in terms of overall level of public intervention, but sufficiently different in terms of composition of expenditures and revenues. A comparison among France, Italy and Sweden seems to have these properties, to a reasonable extent. In 2013 the ratio of public expenditure over GDP ranged between 51% of Italy to 57% of France (Eurostat database[3]). On the other hand, the three systems show some crucial differences. In the typi-

[1] Aaberge and Mogstad (2012) use longitudinal data to measure lifetime income inequality. However they do not assess how lifetime income inequality is affected by public policies.

[2] Another popular tool for the analysis of the redistributive impact of public policies is tax-benefit microsimulation (see, for example, Bourguignon and Spadaro 2006 for an overview). Computational constraints typically prevent OLG models to have the same level of heterogeneity as in microsimulation models. However, in OLG models behavioral responses are structural, while this is not necessarily the case in microsimulation models. Moreover, computable overlapping generations models also provide the opportunity to extend the analysis of inequality to the inter-generational dimension and to take general equilibrium effects into account.

[3] Available at http://ec.europa.eu/eurostat/data/database.

cal categorization of welfare states (Barr, 2004) the three countries belong to three different groups: conservative/corporatist (France), Mediterranean (Italy), social-democratic (Sweden). The composition of social expenditures is quite different across countries, with Italy spending much more on pensions and less on other transfers than the other two countries. On the revenues side, the tax unit for personal income taxation is the family in France, whereas it is the individual in Italy and Sweden. Given that the family is the decision unit in our model, the implications of this difference are particularly interesting to explore. Finally, the fact that social contributions in Italy fund almost exclusively pensions, whereas they also fund other programs in France and Sweden, may also bear relevant redistributive implications.

In this paper we describe the characteristics of the model and we show that it performs well in matching some relevant real world data on some non-calibrated outcomes. We simulate the model to explore the annual and lifetime redistributive effects of the main tax and expenditure programs. The results of this exercise may be relevant to policy-makers wishing to identify the most appropriate reform to target annual or lifetime inequality. We find that lifetime redistribution is generally much lower than annual redistribution, and that ignoring behavioral responses may severely bias the analysis of redistribution.

Heterogenous agents OLG models have already been used to assess the impact of policy reforms. For example, İmrohoroglu *et al.* (1995) and Imrohoroglu *et al.* (1999), Huggett and Ventura (1999), Nishiyama and Smetters (2007), Fehr and Habermann (2008), Fehr *et al.* (2013) study the effect of pension reforms. Ventura (1999), Conesa and Krueger (2006) and Erosa and Koreshkova (2007) analyze the effects of progressive taxation, Nishiyama and Smetters (2005) focuses on consumption taxation, and Conesa *et al.* (2009) study capital income taxation. A recent, relevant trend in computabale overlapping generations models is the expansion of the heterogeneity dimensions, well beyond age and individual productivity, to include for example gender, marital status and the number of children. Models featuring these additional sources of heterogeneity have already been used to study both pension reforms (Hong and Rios-Rull, 2007; Fehr *et al.*, 2012), and tax reforms (Guner *et al.*, 2012a,b). Our framework also includes these modelling features, i.e. we explicitly introduce in the model gender, marital status and the number of children. A first distinctive feature of our analysis is the large number of policies that are simultaneously included in the model. We think that the inclusion of a wide range of taxes and transfers is important not only to study the overall redistributive impact of public intervention; it also matters because the impact of a specific program is likely to depend on the features of the other programs that are in place. In other terms, complementarities/ substitutabilities between different transfers and taxes might exist and ignoring them is a potential source of bias. Moreover we devote specific attention to the difference beetween annual and lifetime redistribution. Finally we apply our model to three European countries: France, Italy and Sweden. To the best of our knowledge, heterogeneous agents computable overlapping generations models have not been used to study the impact of public policies in Italy and France; for Sweden, we are aware of the work by Domeij and Klein (2002), whose focus is on the pension system only.

The structure of the paper is as follows. Section 2 presents the model. Section 3 provides information on the setting of the model parameters. In Section 4 we report results of some numerical experiments on different policy reforms. Finally, we report some concluding remarks in Section 5. Additional information concerning specific aspects of the calibration of model are provided in the Appendix.

2 The model

We consider a small open economy populated by $\overline{J}$ overlapping generations. We denote by $j = \left\{1, 2, ..., J^R, ..., \overline{J}\right\}$ the age of an individual, where J^R is the exogenously fixed retirement age and $\overline{J}$ is the maximum age that can be reached. Individuals may die before age $\overline{J}$, according to a survival probability that will be later specified. We assume that the size of each newborn generation is $1 + n$ times the previous one, where n is assumed to be constant over time. Therefore (since the survival probability function is also assumed to be constant over time), the population structure is stationary and the growth rate of population is equal to n.

Within a generation individuals are heterogenous along several dimensions: gender (males and females), marital status (singles and married), presence of children, educational level. For tractability reasons we make some simplifying assumptions concerning these variables. First, we assume that single individuals never get married and married individuals never get divorced (however, they can become single if their spouses die). Second, we assume that individuals in a couple are of the same age. Finally, it is also assumed that: the number of children is either 0 or 2; only persons living in couple can have children; the birth of children, if any, always occurs when the age of the couple is $j = 1$.

The decision unit is the household. A single makes choices maximizing his or her intertemporal utility. Individuals within a couple pool their resources and maximize the sum of their intertemporal utilities. At any age $j < J^R$ (working period) the household chooses labor supply and consumption of its members; for $j \geq J^R$ (retirement period) only consumption is chosen and labor supply is exogenously set equal to zero. Workers earn a wage per hour of labor that depends on the wage per efficiency units and on the individual number of efficiency units; in turn, efficiency units depend on the age, education level, marital status and number of children of the worker. Efficiency units are also subject to an idiosyncratic shock which is independently distributed across agents. The shock follows a Markov process with transition probabilities denoted by $p(\zeta_{j+1}|\zeta_j)$ where ζ_j is the value of the shock at age j and ζ_{j+1} is the value of the shock at age $j+1$.

There is no aggregate uncertainty and households are assumed to have perfect foresight on the future values of the return on assets and of the wage rate per efficiency unit.

As to the production side, there is only one sector where a good is produced by a representative firm using capital and labor in efficiency units. This good can be used for consumption, investment, purchase of daycare services and it is chosen in each period as the numeraire, i.e., its price is normalized to 1. We assume perfectly competitive markets.

The government is empowered with a large set of policy variables: a personal income tax, a consumption tax, a capital income tax, social contributions, a pension system, a health care system, a child benefit, a subsidy to daycare expenditure and an income support system.

We have uncertainty at the individual level (determined by the stochastic processes for the survival probability and for the efficiency unit of labor), while there is no uncertainty at the aggregate level.

In what follows we specify in more details the features of our model economy. We focus on a steady state equilibrium and therefore we omit time subscripts and we only use the age subscript j. For a summary of the definition of the key variables, see Table C in Appendix C.

2.1 Firms

The output Y is produced by a representative firm according to a Cobb-Douglas technology:

$$Y = AK^{\nu}L^{1-\nu} \tag{1}$$

where A is total factor productivity (assumed constant over time), K is aggregate capital stock, L is aggregate labor supply in efficiency units and $0 < \nu < 1$ is the share of capital income on output.

Profit maximization implies the standard conditions:

$$w = (1-\nu)Ak^{\nu} \tag{2}$$

$$r + \delta = \nu A k^{1-\nu} \tag{3}$$

where w is the wage rate per efficiency unit, r is the return on assets, δ is the depreciation rate of capital and $k \equiv K/L$.

2.2 Households

We assume that each individual has an additively time separable utility function with a momentary utility $u(c_j, z_j)$ defined over consumption c_j and leisure z_j. Individual consumption c_j is equal to the aggregate consumption of the household q_j divided by an equivalence scale θ_j (which depends on the number of adults and children in the household, as specified in Section 3). The momentary utility function of each individual takes the following form:

$$u\left(c_j, z_j\right) = \frac{1}{\left(1 - \frac{1}{\gamma}\right)} \left(c_j^{\left(1-\frac{1}{\omega}\right)} + \alpha z_j^{\left(1-\frac{1}{\omega}\right)} \right)^{\left(\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\omega}}\right)} \tag{4}$$

with:

$$c_j = \frac{q_j}{\theta_j} \tag{5}$$

where γ denotes the intertemporal elasticity of substitution between consumption at different ages, ω defines the intratemporal elasticity of substitution between consumption and leisure at each age j and α is an age-independent leisure preference parameter.

2.2.1 Constraints

For each individual the following time constraint holds:

$$l_j + z_j = 1 \tag{6}$$

where l_j is labor supply and the time endowment is normalized to 1. Equation (6) states that, in each period of life, the time endowment can be used for labor or for leisure time.

Moreover, we assume that a child, in his first period of life (corresponding to age $j = 1$ of parents), requires to be cared all the time; accordingly for every unit of time when both parents work, daycare services must be purchased. Hence, the household demand level for daycare services, d_j, is

$$d_j = \begin{cases} \kappa \min\left\{ l_j^m, l_j^f \right\} & \text{for} \quad j = 1 \\ 0 & \text{for} \quad j > 1, \end{cases} \tag{7}$$

where κ $(= 0, 2)$ is the number of children.

The budget constraint of the household is given by:

$$a_{j+1} = \underbrace{ra_j}_{\text{capital income}} + \underbrace{I_m(g)\left[(y_j^m - sc_j^m(y_j^m)\right] + I_f(g)\left[y_j^f - sc_j^f(y_j^f)\right]}_{\text{labor income net of social contributions}} +$$
$$- \underbrace{t_{y,j}(y_j^m, y_j^f, \kappa_j) - \tau_r ra_j - \tau_q q}_{\text{taxes}} + \underbrace{tr_{\kappa,j}(y_j^m, y_j^f, \kappa_j)}_{\text{child subsidy}} + \underbrace{tr_{y,j}(y_j^m, y_j^f)}_{\text{income support transfer}} +$$
$$- \underbrace{I_m(g)\left[\overline{hs}_j^m - hs_j^m\right] - I_f(g)\left[-\overline{hs}_j^f + hs_j^f\right]}_{\text{net health expenditure}} - \underbrace{p_d(1-\tau_d)d}_{\text{net daycare expenditure}} - \underbrace{q}_{\text{consumption}} +$$
$$\underbrace{\hat{B}_{j+1}}_{\text{accidental bequests}} \tag{8}$$

where a_j denotes assets available at the beginning of period j; $g = m, f$; $I_m(g)$ and $I_f(g)$ are indicator functions; y_j^g denotes labor income; $sc_j^g(y_j^g)$ are social contributions; $t_{y,j}(y_j^m, y_j^f, \kappa_j)$ is the personal income tax paid by the household; τ_r is the tax rate on capital income; τ_q is the tax rate on consumption; $tr_{\kappa,j}(y_j^m, y_j^f, \kappa_j)$ is a child subsidy; $tr_{y,j}(y_j^m, y_j^f)$ is an income support transfer; $\overline{hs}_j^g$ is the exogenous health expenditure needed to maintain a minimum health stock, and hs_j^g denotes the subsidy implicitly provided by the public sector through public health expenditure; p_d is the price of daycare services, τ_d is the subsidy to the purchase of daycare services; $\hat{B}$ denotes accidental bequests, that are assumed to be redistributed equally to working age agents, i.e. $\hat{B}_j = 0$ for $j \geq J^R$, and $\hat{B}_j > 0$ (constant across ages and agents) otherwise.

A crucial variable is clearly income, y_j^g, which is given by:

$$y_j^g = \begin{cases} wl_j^g e_{j,h,ms,\kappa,\zeta}^g & \text{for} \quad j < J^R \\ p_j^g(sb_{J^R}^g) & \text{for} \quad j \geq J^R \end{cases} \tag{9}$$

In equation (9), $e_{j,h,ms,\kappa,\zeta}^g$ stands for efficiency units at age j of an individual of gender g, education level h, marital status ms, number of children κ, receiving an idiosyncratic shock ζ; $p_j^g(sb_{J^R}^g)$ is the pension transfer received by the household and $sb_{J^R}^g$ stands for the amount of pension rights accumulated over the working life.

The rates τ_r, τ_d and τ_q do not depend on individual variables. The subsidy implicitly provided by the public sector through public health expenditure hs_j^g only depends on age. The relationship between income and social contributions, the definition of pension benefits, the personal income tax and cash transfers are country-specific. [4]

We assume that households face a liquidity constraint given by:

$$a_j \geq \bar{a} \quad \forall j \tag{10}$$

and we further assume $\bar{a} = 0$.

2.2.2 Household optimization problem

The optimization problem of singles and couples can be represented using dynamic programming. The state vector of a household is given by:

$$x_j = (h^m, h^f, \kappa_j, \zeta_j^m, \zeta_j^f, a_j, sb_j^m, sb_j^f). \tag{11}$$

We denote by h^g the level of education of an individual of gender g and we use the convention that $h^g \leq 0$ if and only if an individual of gender g is not present in the household; in particular, $h^g = 0$ if an individual of gender g has never been in the household and $h^g < 0$ if an individual of gender g was in the household when the household enters the economy but then died (i.e. $h^g < 0$ identifies the case of a household with a widowed person). Note that, if $h^g = 0$ we obviously have $sb_j^g = 0$, i.e., the amount of pension rights accumulated up to age j by an individual of gender g in that household is zero; moreover, given our assumption that only couples have children, we also have $\kappa_j = 0$, i.e., the number of children is zero. However, if $h^g < 0$, $sb_j^g \geq 0$ (the spouse who died may have accumulated pension rights, that depending on the specific rules of the pension system may give rise to a survivor pension) and $\kappa_j \geq 0$ (children could be born before one of the two spouses passed away). We denote the state vector at age j of a single agent of gender g as x_j^g and of a couple as x_j^{co}.

Note that the educational levels h^g are constant along the life-cycle; the other state variables however do change with age. The number of children κ_j evolves according to an exogenous transition equation:

$$\kappa_{j+1} = \kappa(\kappa_j, j) = \begin{cases} \kappa_j & \text{for} \quad j < J^\kappa \\ 0 & \text{for} \quad j \geq J^\kappa \end{cases} \tag{12}$$

where J^κ is the exogenously fixed age of parents at the time when children become independent.

[4]See Appendix B for a description of the main institutional features of the policies in the three countries we focus on.

As already mentioned, the productivity shock evolves according to a Markov process with transition probabilities $p(\zeta_{j+1}|\zeta_j)$. Transition equations for the remaining state variables are endogenous. Assets a_j change over time according to equation (8). The dynamics of pension rights sb_j^g depends on the legal rules of pension system.

A single with state vector $x_j = x_j^g$ (g=m,f) solves the following maximization problem to determine optimal consumption and leisure decisions:

$$\max_{c_j^g, z_j^g} u\left(c_j^g, z_j^g\right) + \psi_{j+1}\left(g\right) \beta V^g(x_{j+1}^g) \tag{13}$$

where $V^g(x_{j+1}^g)$ is the value function of an agent of gender g at age $j+1$; β is the discount factor (pure time preference), and $\psi_{j+1}\left(g\right)$ is a gender-specific probability of surviving up to age $j+1$, conditional on having reached age j.

Maximization in (13) is carried out subject to the transition equations for the state variables, the liquidity constraint (10) and the time constraint (6).

A married couple with state vector $x_j = x_j^{co}$ determines consumption and leisure from the following maximization problem:

$$\begin{aligned} \max_{q_j, z_j^m, z_j^f} & u\left(c_j^m, z_j^m\right) + u\left(c_j^f, z_j^f\right) + \\ & \psi_{j+1}\left(m\right) \beta \left(\psi_{j+1}\left(f\right) V^m(x_{j+1}^{co}) + \left(1 - \psi_{j+1}\left(f\right)\right) V^m(x_{j+1}^m)\right) + \\ & \psi_{j+1}\left(f\right) \beta \left(\psi_{j+1}\left(m\right) V^f(x_{j+1}^{co}) + \left(1 - \psi_{j+1}\left(m\right)\right) V^f(x_{j+1}^f)\right) \end{aligned} \tag{14}$$

Maximization in (14) is carried out subject to all the constraints relevant for the individual, plus the demand for daycare services constraint (7) and the relationship between household consumption and individual consumption given by equation (5).

The solution to the household optimization problem yields decision rules for consumption $q_j = \hat{q}(x_j, j)$ and labor supply $l_j^g = \hat{l}(x_j, j)$.[5] These in turn imply optimal values of the endogenous state variables $a_{j+1} = \hat{a}(x_j, j)$ and $sb_j^g = \hat{sb}^g(x_j, j)$; using equation (7), we can determine the optimal demand of daycare services $d_j = \hat{d}(x_j, j)$. Moreover the values of taxes and transfers as a function of the state vector and of age can also be computed: $p_j^g = \hat{p}(x_j, j)$, $t_{y,j} = \hat{t}_y(x_j, j)$, $sc_j^g = \hat{sc}^g(x_j, j)$, $tr_{\kappa,j} = \hat{tr}_\kappa(x_j, j)$, $tr_{y,j} = \hat{tr}_y(x_j, j)$.

[5]For household made up by a single male (i.e. $x_j = x_j^m$), we obviously have that $l_j^f = \hat{l}(x_j, j) = 0$; for single female (i.e. $x_j = x_j^f$) it is $l_j^m = \hat{l}(x_j, j) = 0$.

2.3 Government

Describing the household budget constraint (8), we have already mentioned almost all the policy instruments used by the government. In addition to the policy instruments mentioned so far, the government finances a per-capita amount G of government consumption. This is meant to account for the amount of net expenditures (i.e., expenditures minus revenues) which have not been explicitly modelled within our framework. We specify a budget constraint stating that per-capita government consumption $\tilde{G}$ is equal to the difference between all the revenues and the expenditures which are explicitly modelled in our set-up:

$$\tilde{G} = \tilde{T}_y + \tilde{SC} + \tilde{T}_c + \tilde{T}_r - \tilde{P} - \tilde{H} - \tilde{TR}_\kappa - \tilde{TR}_d - \tilde{TR}_y \tag{15}$$

where $\tilde{T}_y$, $\tilde{SC}$, $\tilde{T}_c$ and $\tilde{T}_r$ are respectively per-capita revenues from personal income tax, from social contributions, from consumption tax, and from capital income tax; $\tilde{P}$, $\tilde{H}$, $\tilde{TR}_\kappa$, $\tilde{TR}_d$ $\tilde{TR}_y$ are respectively per-capita public expenditure for pensions, health care, child benefits, daycare services and income support. When we calibrate the model as described in Section 3, the budget balanced condition is reached by adjusting endogenously the level of G. We specify in Section 4 the policy variable which is adjusted to balance the budget when reforms are performed.

2.4 Recursive competitive equilibrium

We are now ready to define the notion of recursive competitive equilibrium in our model economy. We consider a small open economy, we assume that there is no growth in total factor productivity and we focus on a steady state path. The definition of equilibrium is entirely standard. Given the world interest rate $\bar{r}$, a small open economy steady state competitive equilibrium is defined as a collection of factor prices w and r, per-capita capital stock $\tilde{K}$ and per-capita labor in efficiency unit $\tilde{L}$, households' distributions χ_j, households' decision rules, government's revenues and expenditures such that: $r = \bar{r}$, and first order conditions of the firm (2) and (3) holds; market clearing conditions hold; the distribution of households is consistent with individual behavior, i.e, with the transition equations for the state variables implied by the household decision rules; household decision rules are the solution of the dynamic programming problems described by equations (13) and (14); government revenues and expenditures satisfy the government budget constraint (15).

The complexity of the model implies that the solution can only be numerical.

3 Calibration

In this section we describe how parameters are set in order to provide a numerical solution to the model.

3.1 Demographics and education

Individuals enter the model when they are 25 years old. One period in the model is equivalent to 5 years. Individuals live up to a maximum of $\bar{J} = 15$ periods (i.e., the maximum age 100 in years). We set $j^R = 9$ (i.e. the retirement age is 65 years) and $J^\kappa = 5$ (i.e., children become independent and leave their parents when they are 25 years old).

Based on Eurostat population projections for the period 2013-2040, the annual population growth rate is set equal to 0.4% for France, 0.4% for Italy and 0.8% for Sweden.[6] Information related to the exogenous state variables of our model are computed for people belonging to the age group 25-50, using EU-SILC 2008 data. Accordingly, we set the proportion of men with a college degree equal to: 30.33% in France, 14.37% in Italy and 30.85% in Sweden; the corresponding numbers for women are respectively: 36.80% in France, 18.61% in Italy and 41.64% in Sweden. The percentage of households comprising a married couple is 56.95% in France, 66.59% in Italy and 53.70% in Sweden. The fraction of couples with at least one child is 84.21% in France, 82.81% in Italy and the 81.62% in Sweden. Finally we estimate correlations of agents' education levels within couples. The correlations are equal to 0.4309, 0.4130 and 0.3853, respectively for France, Italy and Sweden. These correlations are used to generate couples with a realistic match between education levels of the spouses, using a procedure analogous to that described in Leisch *et al.* (1998).

A proper calibration of survival probabilities should use cohort life tables rather than period life tables. Of course cohort life tables are incomplete for recent cohorts. Using easily available period life tables, however, would generally lead to an under-estimation of life length because of the well-documented downward trend in mortality. To correctly estimate the survival probability, we then apply the Lee and Carter (1992) model to period life tables, separately by gender: to this end we use the Human Mortality Database for

[6] Note that the number of children per household and the growth rate of the population are independently chosen in the calibration of the model. Indeed the assumptions we made in Section 2 on the fertility behaviour (i.e. the maximum amount of children per household is equal to two and singles cannot have children) would imply a negative growth rate of the population. Therefore, to get a positive growth rate of the population, we are actually assuming that in each period there is an inflow of young immigrants.

the period 1979-2008. We focus on the cohort of individuals born in 1989. We use these estimates to parametrize the survival probabilities of retired persons; as to the survival probabilities of the working age population we assume that they are equal to one: this is a minor simplification (since few people die before the age of 65) but it allows to save computational time.

3.2 Preferences and production

We assume that the preference parameters are the same in the three countries and we set the annual discount factor, the intertemporal and intratemporal substitution elasticity (γ and ω) respectively equal to 0.99, 0.2 and 0.4. We then choose α so that the fraction of time devoted to market work is about one third[7] in the three countries we consider, which implies α equal to 1.7 for France, 2.3 for Italy, and 2.1 for Sweden.

The equivalence scale parameter θ is the one used in OECD (2011), that is the square root of the household size. The unitary cost p_d of non parental care is set equal to 8.47 euros per hour in France (see Silvera 2008), 4 euros per hour in Italy (our elaborations on the data provided by Istat 2011) and 8.11 euros per hour in Sweden (see Blomquist *et al.* 2010).

To set the parameter ν, which is the share of capital income on total income, we use AMECO database and accordingly choose $\nu = 0.3930$ for France, $\nu = 0.4170$ for Italy and $\nu = 0.4840$ for Sweden.[8] The annual depreciation rate is chosen equal to 5% and the annual world return on capital $\bar{r}$ is set equal to 8.1%. The small open economy assumption then implies $r = \bar{r}$. Finally, using equations (3) and (2), the total factor productivity parameter A is chosen in such a way that the wage rate per efficiency units w is normalized to 1 (this calibration procedure implies $A = 1.700$ for France, $A = 1.702$ for Italy and $A = 1.685$ for Sweden).

3.3 Efficiency units

In the model efficiency units $e^{g}_{j,h,ms,\kappa,\zeta}$ deterministically depend on age, education level, marital status and the number of children, but are also subject to an idiosyncratic shock following a discrete Markov process.

Note that, since the wage rate per efficiency unit is set equal to one (see Section 3.2), efficiency units are equal to wages per hour of labor. To determine efficiency units we therefore estimate, separately for each country

[7]This is broadly consistent with data on time use for prime age workers (computations based on the Harmonized European Time Use data, https://www.h5.scb.se/tus/tus/)

[8]For these statistics we refer to the average over the period 1960-2016.

and for college and non-college graduates, the wage profile for individual i at age j as the combination of deterministic and stochastic components:

$$\ln(e_{ij}) = x'_{ij}\beta + \epsilon_{ij}, \tag{16}$$

with e_{ij} to denote gross hourly wage, x_{ij} explanatory variables (that is: a set of age dummies, a dummy for gender, for marital status and for children) β parameters and ϵ_{ij} the error term. We further split ϵ_{ij} in persistent and transitory components, respectively η_{ij} and u_{ij}:

$$\epsilon_{ij} = \eta_{ij} + u_{ij} \tag{17}$$

The persistent component follows an AR(1) process,

$$\eta_{ij} = \rho\eta_{ij-1} + v_{ij} \tag{18}$$

Both errors u_{ij} and v_{ij} are assumed iid and mutually independent, with mean 0 and variance σ^2_U and σ^2_V, respectively.

The estimation procedure, applied to the EU-SILC panel dataset (waves 2004-2011)[9], is made of two steps: first, we estimate the parameters of the deterministic component; second, we estimate the parameters of the stochastic components (for additional details see Appendix A).

The parameters estimated on the continuous model can be used to generate shocks for the stochastic wage component. We finally discretize the continuous shock process in a finite-state markov chain using the Tauchen (1986) method.

3.4 Tax and expenditure programs

Here we provide some details on the modelling of public policies for the three countries considered. More details on the modelling of single programs can be found in Appendix B. Despite our goal to provide a coverage of public programs as wide as possible, we exclude some among those of limited size for practical reasons. The list of the programs modelled is reported in Table 1. In modelling policies, the following general rules have been applied. First, for the definition of the different rules of tax and expenditure programs we refer to year 2013. In very few cases, information on 2013 was not available. In that case, we referred to the latest year for which the information could be retrieved. For pensions, we apply to the whole working population the most recently defined set of rules, which are typically those relevant for younger cohorts. Second, we only consider those features of the programs such that

[9] We only consider employees, thus excluding self-employed workers.

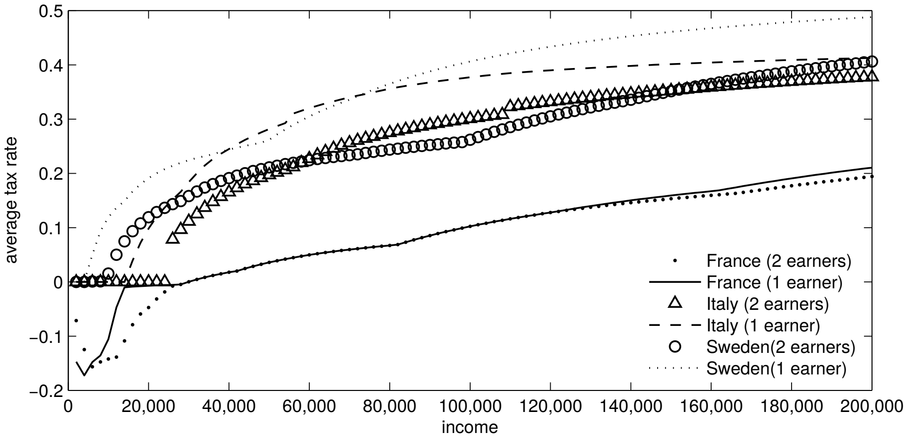


Figure 1: Average tax rate of personal income tax, as a function of family income for a couple with two children

the definition of eligibility an/or of the amount due/received depends on characteristics accounted for in the model. This means that, for example, we do not consider tax credits related to expenditure on specific goods, because we have a single consumption good in the model. Third, only mandatory public programs are covered by our analysis and for the pension system we only explicitly include the pay as you go component.

3.4.1 Taxes

As already mentioned in Section 1, the three countries we consider are quite similar in terms of overall size of public intervention, but are different in terms of institutional features of expenditures and revenues. Concerning taxation, a key difference is that the tax unit for personal income taxation is the family in France, whereas it is the individual in Italy and Sweden. Figure 1 illustrates the implications of the choice of the tax unit on the average tax rate for a family with two spouses and two children. For families with two earners total income is assumed to be equally split between them. For Italy and Sweden the combination of the individual as tax unit and the progressivity of the schedule implies that splitting income between the two earners substantially reduces the average tax rate. This is not the case for France. However, the figure also shows that average tax rates are lower in France than in Italy and Sweden, which is consistent with aggregate data on revenues over GDP. Finally, only in France the tax debit can be negative. This is the result of the introduction in 2009 of the '*Prime pour l'emploi*',

Table 1: List of expenditure and taxation programs modelled

	FRANCE	**ITALY**	**SWEDEN**
Taxes			
Personal income tax	Personal income tax	Personal income tax (central and local)	Personal income tax (central and local)
Social contributions	CSG and other SC related to mandatory pensions, health insurance, family benefits	SC related to mandatory pensions and family benefits	SC related to mandatory pensions and health insurance
Consumption taxation	implicit tax rate on consumption	implicit tax rate on consumption	implicit tax rate on consumption
Capital taxation	implicit tax rate on capital and business income	implicit tax rate on capital and business income	implicit tax rate on capital and business income
Transfers			
Pensions	Earnings related and mandatory occupational pension; survivors' pension	Notional Defined Contribution public pension; survivors' pension	Notional Defined Contribution public pension
Minimum pension	*Minimum contributif*	-	*Garantipension*
Children: in-kind	calibrated subsidy on childcare (see model description)	calibrated subsidy on childcare (see model description)	calibrated subsidy on childcare (see model description)
Children: cash	Family allowance; mean-tested young children allowance; baby bonus; mean-tested education related family benefit	Mean-tested child benefit	Child-benefit (non-mean tested)
Low income support	ASPA, RSA	*assegno sociale* for persons aged 65 and over	–
Health care	average public health expenditure by age	average public health expenditure by age	average public health expenditure by age

a tax credit specifically designed to provide an incentive to increase labour supply for low income individuals. It is worth mentioning that for France we ignore the option that tax payers have to pay taxes on capital income through the system of personal income taxation. This is to avoid double-counting, given that our capital income tax rate is implicit.

For consumption taxation (τ_q) and capital income taxation (τ_r) we use implicit tax rates from Eurostat (2014) for 2012; accordingly we set τ_q equal to 19.8%, 17.7%, 26.5% and τ_r equal to 25.7%, 26.5%, 23.2%, respectively for France, Italy and Sweden.

3.4.2 Public expenditure

For health care we use data from de la Maisonneuve and Martins (2013) to estimate the age profiles of public health expenditure. Data are provided as percentage of GDP per capita for age classes (5 years). These are converted into monetary amounts using data on GDP per capita (reference year 2013) from the national institutes of statistics of the three countries. These values are subsequently rescaled in order to match data from OECD Health Statistics 2014[10] on public health care expenditure over GDP. Since the same data are not available for total (public and private) health expenditure, we assume the same age profile for the private as for the public component. Country specific data on the percentage of private health care expenditure are taken from OECD Health Statistics 2014.

As to daycare, the subsidy provided by the public sector (τ_d) is calibrated so that the overall amount of public expenditure over GDP matches the data. According to the OECD family database,[11] the ratio between public expenditure and GDP in 2009 was 0.4% in France, 0.2% in Italy, 0.9% in Sweden.[12]

Concerning pension systems, those of Italy and Sweden are conceptually very similar, both being '*notional defined contribution*' schemes. There is, however, a large difference concerning the size of the program. According to Eurostat data, in 2012 total public pension expenditure as a ratio of GDP ranges from 11.9% in Sweden to 16.6% in Italy. Of course this also means that social contribution rates are quite different. The standard total

[10] Available at http://www.oecd.org/els/health-systems/oecd-health-statistics-2014-frequently-requested-data.htm.

[11] http://www.oecd.org/els/family/database.htm.

[12] The calibrated values of τ_d are 76%, 50% and 91%, respectively for France, Italy and Sweden. It should be remarked that the ratios of public daycare expenditures to GDP and accordingly the calibrated τ_d, reflect both the percentage of the cost which is publicly financed and the the number of children attending daycare centers.

rate (including the parts due by both the employer and the employee) of pension related social contributions[13] is around 17% in Sweden and around 33% in Italy. Moreover, the Italian system is much more generous in its survivors component and social contributions in Italy fund almost exclusively pensions, whereas they also fund other programs in France and Sweden. The characteristics of the French system are slightly different.[14] The system is based on two tiers. The first is an earnings-related public pension, where the pension benefit depends on the annual average reference salary of 25 best salary years indexed to prices; reductions are applied when the number of quarters of contribution is less than 166[15]. The second tier is a mandatory occupational pension scheme with a defined benefit component. In this case the benefit is based on a points system.

As to other social expenditures, public intervention is far less extensive in Italy than in France and Sweden. This is basically true for all ages. For example, Italy is the only country with no transfer made to families with dependent children irrespective of economic conditions, and with no low income support program accessible irrespective of age.[16] In Italy there exists also no program to guarantee a minimum pension.

3.5 Data matching

The model seems to be able to match reasonably well some important aggregate and distributional features of the three countries. Table 2 shows the ratios between the main tax and expenditure programs and GDP generated by the model and their empirical counterpart computed as an average of the available data for years 2005-2012.[17] In the model, only public daycare

[13]Note that in all countries there exist thresholds above and below which the rate changes and may even go to zero.

[14]In France, there are non negligible differences between the rules for public and private employees. Since this is not a dimension of heterogeneity in our model, we refer to the rules that apply to the private sector.

[15]In our model one period is equal to 5 years. Therefore it is not possible to model directly this feature of the pension system. To indirectly take it into account, we calibrate the liquidation rate of pension benefits in order to match the replacement rate of the public pension system. To this end we use the projections for 2060 reported in AWG (2012).

[16]Only people older than 65 are eligible to the only program targeted to poverty (*assegno sociale*). In Sweden, a similar program of limited size exists (approximately 0.3% of GDP). However, we do not model it (see Table 1), because ownership (or not) of a house is a key determinant of the eligibility in reality, whereas it is not accounted for in our model.

[17]Data concerning revenues are taken from Eurostat (2014). As to the expenditures on pensions, we consider the ageing working group (AWG) projections for 2060 (AWG 2012). Indeed for all the three countries, we model the most recent pension rules, that will need some decades to show their effects on aggregate data.

Table 2: Main Taxes and Expenditures (% of GDP)

	France		Italy		Sweden	
	Model	Data	Model	Data	Model	Data
Consumption Tax	12.1%	11.0%	9.7%	10.6%	11.8%	12.8%
Capital Income tax	8.3%	5.5%	6.4%	7.8%	6.7%	5.1%
Personal Income Tax	5.1%	7.9%	10.2%	11.4%	13.0%	16.5%
Social security contributions	17.3%	16.6%	16.0%	13.1%	8.1%	8.5%
Pensions (old age)	12.9%	12.3%	16.7%	11.8%	7.0%	6.6%
Government Consumption	18.3%	16.2%	16.9%	20.6%	22.8%	24.2%

expenditures and public health care expenditure as a share of GDP are calibrated to match their empirical counterpart. Hence, there is no guarantee that the other public finance programs are able to match real data. However, we can see that the model is able to reproduce reasonably well the data for all the three countries. The last row of the Table reports the value of "Government consumption" G, which is simply the difference between all the revenues and the expenditures which have been explicitly modelled in our set-up. Therefore, the difference between the values of G predicted by the model and those computed on the data can be used to get aggregate measure of how the model is able to replicate the public finance data. We can see that the difference is pretty small for all the three countries we consider.[18]

Then, we look at the ability of our model economy to reproduce some distributional features of the economies of France, Italy and Sweden.[19]

[18]It is noteworthy that the difference between "model" and "data" for the personal income tax in France (2.8%) corresponds, with opposite sign, to the difference on capital income taxation. This is due to the fact French tax payers have an option to pay taxes on capital income through PIT, which is not accounted for in the model, for the reasons that were previously explained.

We can also note that a likely explanation of the difference between "model" and "data" for social contributions and pension benefits in Italy, could be an higher degree of contribution evasion in Italy than in France and Sweden. To the best of our knowledge there are no comparable estimates of contribution evasion for the three countries. However there are data pointing to a greater importance of the whole shadow economy for Italy than for France and Sweden (Schneider *et al.* (2010)) and contribution evasion is arguably correlated with the level of the shadow economy.

[19]Data on the distribution of income are computed using EU-SILC 2008. These computations have been made on a sample which excludes households with self employed workers (in order to be consistent with the sample used for the estimation of individual labor productivity; see Section 3.3) and people younger than 65 but retired (to be consistent with

Table 3: Statistics: Income (Gini)

	France		Italy		Sweden	
	Model	Data	Model	Data	Model	Data
Gross income (working age)	0.295	0.307	0.260	0.303	0.242	0.291
Gross income	0.328	0.418	0.321	0.438	0.271	0.420
Capital income	0.523	0.820	0.526	0.752	0.499	0.832

Table 3 compares the value of the Gini coefficient generated by the model with the data, in terms of gross income and capital income. The model performs well in reproducing the Gini coefficient of gross income during working age (first row of the Table), while it does a poorer job concerning gross income of the whole population (second row of the Table). As can be understood looking at the last row of the table, the reason is that the distribution of capital income in the data is more concentrated than the distribution of capital income produced by the model. On the other hand, as shown in Table 4, the model generates a realistic distribution of earnings.

As stressed by De Nardi (2015), many quantitative models used for policy analysis produce a distribution of capital income that is much less concentrated than the distribution found in the available data. At the moment, there is no consensus on the appropriate savings mechanism that can be used to correctly reproduce the distribution of capital income and the different mechanisms that have been proposed have quite different policy implications. Among the competing savings theory, an important role is played by those theories pointing to the importance of intergenerational transfers of wealth. We view the introduction of intergenerational transfers as a possible extension of the model presented in this paper.

4 Numerical experiments

The model we described in the previous sections can be used for many purposes: a wide range of policy reforms can be simulated in order to assess their impact along several dimensions. In particular, it is possible to simulate both marginal reforms, where policy parameters are changed by a small amount, and more radical reforms. In performing these policy experiments either a positive or a normative approach can be adopted.

the model, which does not allow retirement before that age).

Table 4: Statistics: Earnings (Working Age)

	France		Italy		Sweden	
	Model	Data	Model	Data	Model	Data
Gross earnings: Gini	0.307	0.295	0.269	0.301	0.284	0.289
Gross earnings: P90/P10	4.786	4.069	3.596	4.249	4.096	3.995
Gross earnings: P90/P50	1.973	1.845	1.868	1.839	1.818	1.753
Gross earnings: P75/P25	2.414	1.846	2.025	1.993	2.076	1.914
Gross earnings: P10/P50	0.412	0.453	0.520	0.433	0.444	0.439

In this Section, we focus on radical reforms with a positive approach. In particular, we examine the redistributive properties of a specific program with respect to annual and lifetime inequality. To this end, we compare the steady state Gini coefficient obtained including all programs, with the one obtained including all programs but the one under evaluation. When an expenditure program is removed to assess its redistributive properties, also social contributions, if any, that are explicitly used to finance those benefits, are removed. We also study the impact of removing simultaneously all the policies currently in place in the three countries considered. Specifically, we study the redistributive impact of:

- personal income taxation
- capital income taxation
- consumption taxation
- subsidy to daycare
- child benefits
- health care
- low income support
- pensions
- all the above together

It should be stressed that the effect of removing a policy obviously depends on how the government budget constraint (15) is adjusted to keep it balanced. For instance, when the reform removes a tax, it makes a difference for the impact of the reform itself, if the government budget is balanced raising another tax, reducing a transfer, or reducing the government consumption G. Our approach is to use a proportional tax (subsidy) on disposable income and to set its rate so that the value of the exogenous revenue requirement, G, is the same as before removing the program.[20]

Moreover we want to point out that the removal of one policy indirectly affects the remaining public programs for two reasons. On the one hand, there is a mechanical impact (for instance, when the pension system is removed, revenues from the personal income tax are affected); on the other hand, there is a behavioral impact: when the policy is removed, labor supply and savings change, thus inducing a potential modification in the size of all the other programs. The results we present in this section take both impacts into account.

Table 5 reports the difference between the Gini coefficient of disposable income in the steady state after the policy reform (exclusion of the program) and that in the initial steady state. Therefore, a positive (negative) number means that the specific program reduces (increases) inequality in disposable income. The same results are illustrated in Figure 2.

In general, the results shows that the differences between annual and lifetime redistribution may be large, thus suggesting that policy makers wishing to undertake reforms to reduce inequality should be aware of which dimension of inequality is targeted. This will affect the selection of the most effective policy tool.

In all three countries, the most redistributive program (on both annual and lifetime basis) is the personal income tax. Looking at annual redistribution, we note that the ranking between the other programs is very similar for France and Italy whereas Sweden shows some relevant differences. This means that not only the choice of the program to implement is important to achieve the desired redistributive results, but also its design and size. For example, the very large redistributive impact of daycare subsidization in Sweden on an annual basis is noteworthy and it makes it the second most redistributive program on an annual basis for that country. Other peculiarities of Sweden when compared with the other two countries include a comparatively large impact of consumption taxation and a small one for capital taxation and pensions. Concerning pensions, the size of the program is likely to play a major role here: Sweden has by far the lowest pension expenditure

[20] In the absence of any behavioral response, a proportional tax (subsidy) on disposable income would be neutral in terms on redistribution: it would allow to balance the budget constraint without having its own impact on inequality of disposable income. Such an impact only appears because agents change their labor supply and their saving following the introduction of this tax (subsidy).

over GDP (see Table 2) among the three countries. A final consideration is that Sweden is the only country where, on an annual basis, all programs reduce inequality in disposable income.

Moving to the lifetime perspective, we note that difference with respect to annual redistribution is, as expected, higher for programs that are targeted to very specific phases of the life-cycle, such as pensions, daycare and child benefits. For some of these programs the sign of the redistributive impact may even become negative in switching from annual to lifetime redistribution. This is the case for daycare subsidization in France, child benefits in Sweden and of the pension system both in France and in Sweden. For day care and for the child subsidy it is not surprising that our measure of lifetime redistribution could be negative: indeed there is no obvious relationship between having children and lifetime income. As to the impact of the pension system on lifetime inequality, it is noteworthy that France and Sweden share more similarities than Italy, notwithstanding the fact that both Italy and Sweden have a notional defined contribution system. This finding suggest that the impact of a policy not only depend on the features of that specific policy, but also on the other policies that turn out to interact with it.

The combination of the above characteristics is such that, looking at the overall redistributive impact of public policies (last row of the Table), redistribution on annual basis is higher in Sweden than in France and in Italy. This is essentially the results of two features that have already been mentioned: the fact that, unlike for the other two countries, all programs reduce inequality on an annual basis, and the large, positive impact on redistribution of personal income taxation. On the other hand, if lifetime redistribution is considered, the ranking of overall redistribution changes: Italy is redistributing more than Sweden and France. Indeed the difference between annual and lifecycle redistribution is higher in the last two countries than in Italy.

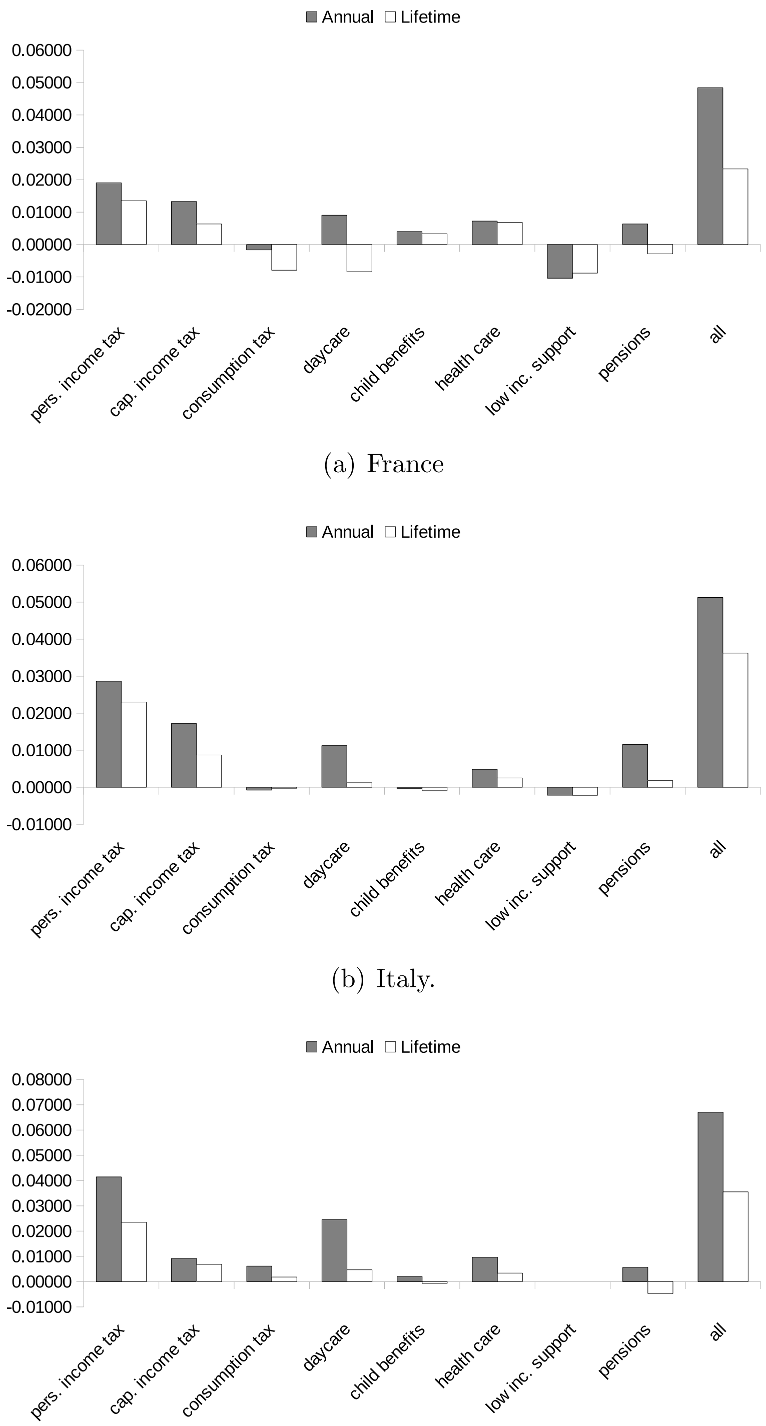
Finally, to better understand the redistributive impact of the different policies, we disentangle the role of the policy itself from that of behavioural responses. Indeed the effect of a policy reform on inequality can be thought as being determined by two effects: first the impact of the reform assuming that individual behaviour is unaffected by reform itself; second the impact of the reform on agents' incentives and thus on their behaviour. To this end, after having computed in Table 5 the effect of a policy reform on the steady state equilibrium of our model economy, we also compute in Table 6 the impact of the reform assuming that individual behaviour (consumption and labor supply in our model) is fixed at the initial steady state equilibrium. This analysis is useful, for instance, to understand one of the results in Table 5 that could seem surprising and counter-intuitive at a first glance: the transfer targeted to poor people, that is commonly thought to redistribute from "the rich to the poor", according to Table 5 is actually redistributing in the opposite direction. Such a "puzzling" finding disappears when we do not take behavioural responses into account (see Table 6 and the equivalent Figure 2): the income support programme is, as expected, reducing disposable income inequality. Indeed the result of Table 5 depends on poor agents raising their labor supply after the removal of the policy targeted to them: accordingly the distribution of gross labor income is more equal; this effect turns out to be strong enough to make also the distribution of disposable income more equal, even if the programme targeted to poor people has been removed. More generally, the comparison between Table 5 and 6, allows to understand how important behavioural response might be for a proper assessment of the redistributive impact of the different public policies.

Table 5: Redistributive impact of public policies

	France			Italy			Sweden		
	Annual	Lifecycle	Ratio	Annual	Lifecycle	Ratio	Annual	Lifecycle	Ratio
Personal Income Tax	0.01905	0.01351	0.70920	0.02866	0.02302	0.80327	0.04147	0.02351	0.56687
Capital Tax	0.01328	0.00633	0.47689	0.01720	0.00871	0.50629	0.00917	0.00683	0.74487
Consumption Tax	-0.00167	-0.00793	4.75133	-0.00078	-0.00028	0.35938	0.00614	0.00182	0.29587
Daycare Subsidy	0.00904	-0.00840	-0.92899	0.01124	0.00122	0.10859	0.02453	0.00468	0.19085
Child benefit	0.00400	0.00331	0.82666	-0.00038	-0.00094	2.44126	0.00204	-0.00070	-0.34196
Health care expenditure	0.00724	0.00683	0.94307	0.00484	0.00251	0.51791	0.00968	0.00338	0.34947
Low income support	-0.01040	-0.00883	0.84901	-0.00216	-0.00218	1.00796	-	-	-
Pension system	0.00634	-0.00289	-0.45510	0.01156	0.00179	0.15451	0.00564	-0.00471	-0.83483
All	0.04841	0.02334	0.48210	0.05127	0.03624	0.70692	0.06705	0.03554	0.53010

Table 6: Redistributive impact of public policies when behavioral responses are not taken into account

	France			Italy			Sweden		
	Annual	Lifecycle	Ratio	Annual	Lifecycle	Ratio	Annual	Lifecycle	Ratio
Personal Income Tax	0.01393	0.01129	0.81045	0.02058	0.01565	0.76065	0.02388	0.00988	0.41388
Capital Tax	0.01610	0.01354	0.84051	0.01605	0.00947	0.58972	0.01091	0.00737	0.67528
Consumption Tax	0.00000	0.00000	-0.06175	0.00000	0.00000	1.80645	0.00000	0.00000	-0.08364
Daycare Subsidy	0.00746	-0.00442	-0.59280	0.01065	0.00333	0.31291	0.01614	0.00316	0.19579
Child benefit	0.00663	0.00382	0.57631	0.00904	0.00492	0.54371	0.00441	0.00001	0.00290
Health care expenditure	0.01657	0.01541	0.93044	0.00642	0.00810	1.26305	0.01343	0.00568	0.42323
Low income support	0.00811	0.01103	1.35962	0.00026	0.00004	0.17055	-	-	-
Pension system	0.03721	0.00901	0.24208	0.04537	0.00184	0.04055	0.02320	-0.00292	-0.12606
All	0.12324	0.06253	0.50740	0.12556	0.04209	0.33521	0.09583	0.03067	0.32010

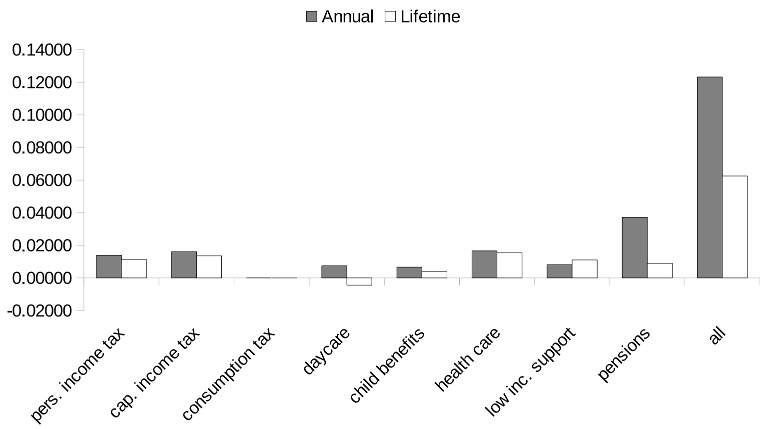


(a) France

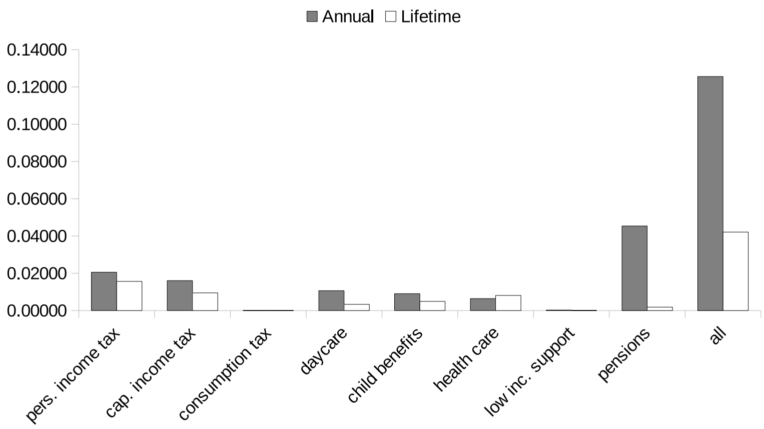
(b) Italy.

(c) Sweden.

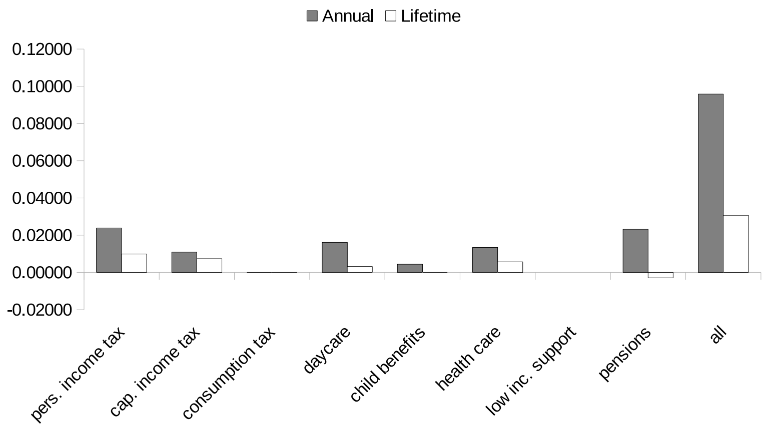
Figure 2: Redistributive impact of public policies



(a) France



(b) Italy.



(c) Sweden.

Figure 3: Redistributive impact of public policies when behavioral responses are not taken into account

5 Conclusion

This paper uses a large scale overlapping generation model to asses the impact of the main tax and expenditure programs on inequality. The model is applied to three countries: France, Italy and Sweden. The analysis may be valuable for policy makers in choosing the most appropriate tool to achieve specific redistributive goals.

Specifically, we compare our model economies featuring the current set of public policies implemented in the three countries, with alternative economies where some or all the public finance programs are absent. The comparison is made in terms of both annual and lifetime redistribution. Our results confirm that not only annual and lifetime redistribution are conceptually separated, but also the level of redistribution achieved by a specific program is largely different depending on which type of redistribution is considered. This is obviously true for programs that are targeted to very specific phases of the life-cycle, such as pensions, daycare and child benefits. However the difference between annual and lifetime redistribution can also be sizeable for other programs (e.g. the personal income tax). Our results also suggest that behavioral responses play a major role when assessing the redistributive impact of a policy and should be carefully taken into account: for instance, policies such as the low income support subsidy that are redistributive in absence of behavioural responses, could rise inequality when agents' reactions to incentives are considered.

In the paper we focus on the long run effect of the policy reforms, therefore abstracting from the transition dynamics. Transition dynamics is however an important issue, especially for those reforms which affect the pension system. We therefore plan to include it in a future extension of the model.

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A Estimation of the the wage process

Here we report the details of the estimation of the wage process characterized by equations (16), (17) and (18).

A.1 Deterministic component

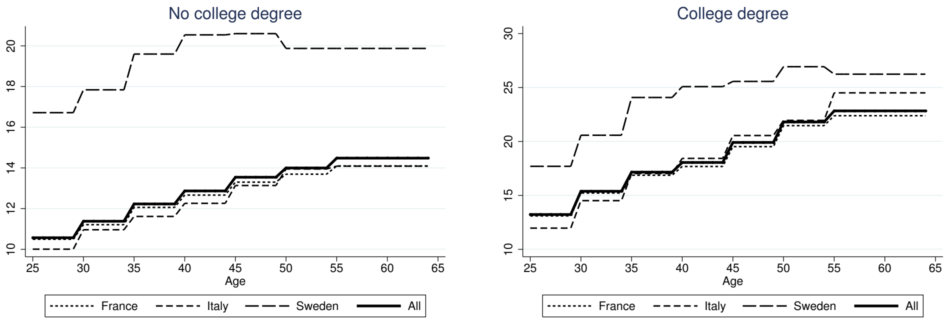

Figure A1: Average wage profile

We estimate the parameters β of the deterministic component from a random-effect GLS regression of equation (16) to deal with panel data. The random-effect model is preferred to a fixed-effect model because we need estimates of coefficients on time-invariant variables such as gender.

The specification includes a set of 5-year range age binary variables (chosen to be consistent with the model structure; the reference category is the age range 55-59), and binary variables on having children in age 0-5, in age 6-18, being male, and being married. These variables capture the heterogeneity of individual characteristics in the model. Finally, the specification controls for time effects by means of year binary variables.

Table A1 and Table A2 show the results of the estimates, separately for non-college and college graduates; similarly, Figure A1 plots the predicted age-wage profile for an individual with average characteristics, from the regression of Table A1 and Table A2. We notice that wages grow following a roughly linear trend.[21] Sweden shows generally higher wages, which also grow more quickly over the years: the average growth rate is 1.8% per year for college graduates as opposed to 1.1% per year for non-college graduates.

[21] In fact, estimates are similar if we replace the age binary variables with one age linear trend.

Table A1: Deterministic profile, no college degree

	(1) France	(2) Italy	(3) Sweden	(4) Overall
age 25-29	-0.295***	-0.342***	-0.173***	-0.315***
	(0.014)	(0.010)	(0.015)	(0.008)
age 30-34	-0.229***	-0.251***	-0.108***	-0.241***
	(0.012)	(0.009)	(0.013)	(0.007)
age 35-39	-0.156***	-0.193***	-0.014	-0.169***
	(0.011)	(0.009)	(0.013)	(0.006)
age 40-44	-0.107***	-0.139***	0.033***	-0.118***
	(0.011)	(0.008)	(0.012)	(0.006)
age 45-49	-0.058***	-0.070***	0.036***	-0.067***
	(0.010)	(0.008)	(0.012)	(0.006)
age 50-54	-0.029***	-0.010	-0.000	-0.034***
	(0.008)	(0.007)	(0.010)	(0.005)
n. children 0-5	-0.028***	0.008*	-0.112***	-0.021***
	(0.006)	(0.005)	(0.007)	(0.003)
n. children 6-24	0.001	0.007**	0.021***	0.004*
	(0.004)	(0.003)	(0.005)	(0.002)
male	0.240***	0.102***	0.176***	0.213***
	(0.007)	(0.005)	(0.007)	(0.004)
married	0.016**	0.019***	0.052***	0.013***
	(0.008)	(0.006)	(0.008)	(0.005)
year 2003			-0.312***	-0.027
			(0.017)	(0.035)
year 2004	-0.014		-0.271***	-0.005
	(0.227)		(0.011)	(0.021)
year 2005	-0.026***		-0.252***	-0.033***
	(0.006)		(0.008)	(0.004)
year 2006	-0.011**	-0.005	-0.221***	-0.017***
	(0.005)	(0.003)	(0.007)	(0.003)
year 2008	-0.009*	-0.018***	-0.040***	-0.012***
	(0.005)	(0.003)	(0.007)	(0.003)
year 2009	0.003	-0.022***	-0.124***	-0.007**
	(0.006)	(0.004)	(0.008)	(0.003)
year 2010	0.023***	-0.011***	-0.008	0.016***
	(0.006)	(0.004)	(0.009)	(0.004)
year 2011	0.026***	-0.018***	-0.127***	0.011**
	(0.009)	(0.006)	(0.012)	(0.005)
Constant	2.330***	2.436***	2.723***	2.374***
	(0.011)	(0.010)	(0.012)	(0.007)
Households	26,611	35,337	15,713	77,661
Observations	77,556	89,057	42,871	209,484

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: Deterministic profile, college degree

	(1) France	(2) Italy	(3) Sweden	(4) Overall
age 25-29	-0.536***	-0.717***	-0.394***	-0.546***
	(0.016)	(0.021)	(0.020)	(0.011)
age 30-34	-0.386***	-0.524***	-0.243***	-0.395***
	(0.015)	(0.018)	(0.019)	(0.010)
age 35-39	-0.283***	-0.364***	-0.086***	-0.286***
	(0.015)	(0.018)	(0.019)	(0.010)
age 40-44	-0.236***	-0.285***	-0.045**	-0.235***
	(0.015)	(0.017)	(0.020)	(0.010)
age 45-49	-0.137***	-0.176***	-0.026	-0.137***
	(0.015)	(0.017)	(0.019)	(0.010)
age 50-54	-0.042***	-0.110***	0.026	-0.046***
	(0.014)	(0.016)	(0.017)	(0.009)
n children 0-5	0.017***	0.007	-0.154***	0.009**
	(0.006)	(0.010)	(0.009)	(0.004)
n children 6-24	0.022***	0.047***	0.028***	0.024***
	(0.005)	(0.007)	(0.007)	(0.004)
male	0.166***	0.141***	0.305***	0.171***
	(0.008)	(0.011)	(0.011)	(0.006)
married	0.072***	0.097***	0.055***	0.074***
	(0.009)	(0.013)	(0.012)	(0.006)
year 2003			-0.293***	-0.050
			(0.028)	(0.054)
year 2004			-0.292***	-0.061*
			(0.017)	(0.031)
year 2005	-0.003		-0.278***	-0.016***
	(0.008)		(0.013)	(0.006)
year 2006	-0.009	0.012	-0.230***	-0.019***
	(0.007)	(0.008)	(0.011)	(0.005)
year 2008	-0.001	-0.006	-0.067***	-0.005
	(0.007)	(0.008)	(0.011)	(0.005)
year 2009	0.000	-0.008	-0.139***	-0.007
	(0.007)	(0.009)	(0.012)	(0.005)
year 2010	0.018**	-0.070***	-0.010	0.010*
	(0.008)	(0.010)	(0.013)	(0.006)
year 2011	0.032***	-0.096***	-0.134***	0.013*
	(0.011)	(0.012)	(0.016)	(0.008)
Constant	2.805***	2.912***	2.932***	2.822***
	(0.015)	(0.019)	(0.019)	(0.010)
Households	14,148	7,703	9,846	31,697
Observations	41,634	19,053	27,068	87,755

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A.2 Stochastic component

We exploit the fact that

$$m_k = E\left[\epsilon_{it}\epsilon_{it-k}\right] = \begin{cases} \sigma_U^2 + \sigma_H^2 & k = 0 \\ \rho^k \sigma_H^2 & k > 0 \end{cases} \tag{19}$$

to estimate the stochastic parameters $\theta = \begin{bmatrix} \rho & \sigma_H^2 & \sigma_U^2 \end{bmatrix}'$ where $\sigma_H^2 = \frac{\sigma_V^2}{1-\rho^2}$ using a minimum distance approach from the minimization of the moment condition[22]

$$M(\theta) = \begin{bmatrix} \sigma_U^2 + \sigma_H^2 \\ \rho\sigma_H^2 \\ \rho \end{bmatrix} - \begin{bmatrix} \widehat{m}_0 \\ \widehat{m}_1 \\ \frac{\widehat{m}_2}{\widehat{m}_1} \end{bmatrix} \tag{20}$$

where $\widehat{m}_k$ is the sample estimate of m_k based on the residuals of the regression in the first step.

The variance of the estimated vector $\widehat{\theta}$ is given by

$$V\left(\widehat{\theta}\right) = \left(D'D\right)^{-1} D'HD\left(D'D\right)^{-1} \tag{21}$$

where

$$D = \frac{\partial M(\theta)}{\partial\theta} = \begin{bmatrix} 0 & 1 & 1 \\ \sigma_H^2 & \rho & 0 \\ 1 & 0 & 0 \end{bmatrix} \tag{22}$$

$$H = V\left(\sqrt{N}M(\theta)\right)^{-1} \tag{23}$$

with N denoting the number of observations, that we replace with the sample counterpart.

Table A3 and Table A4 report the estimates of the stochastic component parameters, separately for non-college and college graduates. The two tables also report the variance $\widetilde{\sigma}^2$ of the residuals $\widehat{\epsilon}_{it}$ in the age range 25-29; this information is used to generate an initial distribution of wages at the beginning of adult age.

The AR(1) coefficient ρ is well below 1, especially in Sweden, indicating that shocks last over several years but are not permanent. The dispersion of wages at the beginning of the career is also higher in Sweden and lower in Italy.

[22] We consider an equally-weighted estimator.

Table A3: Stochastic component parameters, no college degree

	(1)	(2)	(3)	(4)
	France	Italy	Sweden	Overall
ρ	0.861	0.848	0.714	0.864
	(0.005)	(0.014)	(0.012)	(0.003)
σ_H^2	0.250	0.200	0.192	0.243
	(0.006)	(0.018)	(0.018)	(0.004)
σ_U^2	0.123	0.058	0.099	0.112
	(0.007)	(0.022)	(0.020)	(0.005)
$\widetilde{\sigma}^2$	0.354	0.284	0.445	0.349
Households	26,611	35,337	15,713	77,661
Observations	77,556	89,057	42,871	209,484

Table A4: Stochastic component parameters, college degree

	(1)	(2)	(3)	(4)
	France	Italy	Sweden	Overall
ρ	0.893	0.838	0.697	0.875
	(0.014)	(0.030)	(0.016)	(0.010)
σ_H^2	0.170	0.194	0.240	0.177
	(0.018)	(0.046)	(0.023)	(0.013)
σ_U^2	0.149	0.071	0.165	0.144
	(0.018)	(0.058)	(0.025)	(0.013)
$\widetilde{\sigma}^2$	0.341	0.374	0.562	0.356
Households	14,148	7,703	9,846	31,697
Observations	41,634	19,053	27,068	87,755

A.3 Use of the estimates in the model

Estimates of the β parameters generate the deterministic wage component as a function of the observable characteristics; estimates of the $\theta = \left[\begin{array}{ccc} \rho & \sigma_H^2 & \sigma_U^2 \end{array} \right]'$ parameters generate shocks for the stochastic wage component. We then discretize the continuous shock process in a finite-state markov chain using the method suggested by Tauchen (1986).

A concern is that our estimates are obtained from data observed at the annual frequency, while the model is scaled on a five-year time span. This is not an issue for the deterministic component – since the specification makes use of five-year age dummies – but gives rise to potential inconsistency on the stochastic component.

To overcome this problem, the AR(1) process of the stochastic component in the code actually involves

$$\begin{aligned} \eta_{it} &= \rho\eta_{it-1} + v_{it} \\ &= \rho\left(\eta_{it-2} + v_{it-1}\right) + v_{it} \\ &= ... \\ &= \rho^5\eta_{it-5} + \left(v_{it} + \rho v_{it-1} + \rho^2 v_{it-2} + \rho^3 v_{it-3} + \rho^4 v_{it-4}\right) \\ &= \rho^5\eta_{it-5} + \widetilde{v}_{it}. \end{aligned} \tag{24}$$

In practice, this means that in the code: i) the AR(1) coefficient is ρ^5 rather than ρ; ii) the variance of the persistent shock is $(1 + \rho^2 + \rho^4 + \rho^6 + \rho^8)\,\sigma_V^2$ rather than σ_V^2.

B Tax and expenditure programs

B.1 France

B.1.1 Pension system

The French pension system consists of three pillars:

1. The first pillar is mandatory and publicly managed. It includes:
   (a) an earnings-related public pension;
   (b) a mandatory occupational pension scheme, based on a points system;
   (c) a contributory minimum pension.

2. The second pillar is voluntary and privately managed and consists of few company schemes and numerous collective insurance contracts, usually managed in small and medium enterprises.

3. The third pillar is voluntary and privately managed. It was established in 2004 and consists of individual, supplementary subsidized pension savings plans.

For France as well as for the other countries, we only model the mandatory component of the pension system.The additional components can be thought of as part of voluntary savings. Moreover, since we do not differentiate between self-employment and dependent work, we refer to the rules that apply to dependent workers in the private sector. We now move to the description of how the first pillar is characterized in the model, starting from the definition of the amount of social contributions due.

Earnings-related public pension:

Contributions related to this tier are made up of two components:

- a rate of 15.15% (6.75% paid by the employee and 8.40% paid by the employer; reference year is 2013) up to an income ceiling of 3,086 euros per month;
- an additional contribution of 1.7% (0.1% paid by the employee and 1.6% by the employer) to be paid on the whole gross salary, even above the social security ceiling.

Minimum retirement age is currently 61, but it is due to gradually increase to 62 by 2017. We set retirement age at 65.

The following formula defines the pension benefit (P) for this tier:

$$P = (T - tn) * (D/160) * SAM$$

where T is the liquidation rate equal to 50%; t is the abatement rate, equal to 1.25% per quarter of missing insurance; n is the number of missing quarters from a maximum of 160-166 (depending on the year of birth);[23] D is the insurance period under the general scheme with a limit of 160-166 quarters; the Salaire Annuel Moyen (SAM) is the annual average reference salary of 25 best salary years indexed to prices. Benefits in the basic scheme are also indexed to prices. Rules are somewhat different for civil servants, for whom

[23] Consistent with the general rule of modelling the rules of pension systems that apply to the younger cohorts, we set this value to 166.

they tend to be more favourable. Public employees are not differentiated from private ones in our model. A precise implementation of this component of the French pension system would require additional state variables, to characterize such aspects as the number of quarters of contribution and the sector the worker belongs to (private *vs.* public). To avoid the additional computational burden that this would imply, we calibrate the abatement rate in such a way that the replacement rate in the model is consistent with official forecasts (European Commission, 2012) for the general population (private and public sector employees). We include in the model the possibility of receiving survivors' pension. In the French pension system the award of this type of benefit to a surviving spouse is not automatic but subject to specific conditions of age and income. Such pensions are paid to surviving spouses or surviving former spouses aged at least 55, whose income is below a given level. The amount of the survivors' pension may not exceed 54% of the deceased spouse's pension or the pension to which the deceased spouse would have been entitled.

Mandatory occupational pension scheme:

This is a mandatory defined benefit component of the pension system. There are two different pension schemes in France: the ARRCO (Association pour le régime de retraite complémentaire des salariés) and the AGIRC (Association générale des institutions de retraite des cadres). We only refer to the former, as it covers a wider population. However, there are very small differences between the two schemes.

Contribution rates are defined as follows for this second tier. The contribution rate is 7.5% of the gross wage (3% employee and 4.5% employer), up to the social security ceiling (3,086 euros per month in 2013). The rate is 20% (8% employee e 12% employer) up to three times the ceiling (9,258 euros per month in 2013).

The calculation of the pension benefit is based on a points system. The following formula defines the amount of the pension benefit:

$$P = \left(\frac{\sum w \cdot cr}{PP}\right) \cdot PV \cdot RC(\text{age, contribution period})$$

where $w \cdot cr$ is the amount of social contributions paid, PP and PV are the price per point and the point value respectively, and RC is the reduction coefficient. We keep the same retirement age as for the first tier (65) and assume $RC = 1$. Moreover, we keep PP and PV constant, equal to the 2012 values, i.e. respectively 15.0528 euros and PV 1.2344 euros.

Contributory minimum pension:

This benefit is a minimum pension in the regime general and in related schemes regardless of the amount of pension received from other basic or supplementary schemes. To be eligible for this pension, 41.5 years of contributions, or being aged 65 and over (planned to be extended to 67 from 2023) are needed (the minimum pension is pro rated for shorter period). In 2013 the monthly amount is 628.99 euros, it is increased to 687.99 euros when the pensioner has contributed at least 120 quarters.

B.1.2 Low income support

Solidarity allowance for the elderly - ASPA:

Persons aged more than 64 and with limited resources are eligible to ASPA (Allocation de solidarité aux personnes agées), whose amount is defined in the following way:

$$\text{ASPA} = \text{Monthly Maximum amount} - \text{Quarterly Family income}/3$$

Consistently with what was done elsewhere, we refer to 2013 for the definition of the maximum monthly income (787.26 euros for a single and 1,222.27 euros for a couple).

Solidarity labor income - RSA:

In order to be eligible for this programme, the individual must be aged between 26 and 64 (i.e. not be eligible for ASPA). Youths 18-25 years of age and without children are eligible if they have worked for at least two years out of the last three years. The transfer equals the difference between the maximum RSA (lump sum plus 62% of net household income from work) and the household income (calculated on the last quarter).[24]

B.1.3 Family benefits

The following social benefits are modeled for France:

[24]Hence, the programme ensures that all those who are eligible receive at least the minimum income. The lump sum is determined by the household composition and the number of dependent children. Referring to the family composition relevant to our model in 2013 the value of the (monthly) minimum income is 483.24, 724.86 and 1014.80 euros respectively for singles without children, couples without children and couples with two children.

Table B1: Income thresholds for PAJE

	Income threshold
One earner couples	
One dependent Child	34,819
Two dependent Children	41,783
Two earner couples or lone parents	
One dependent Child	46,014
Two dependent Children	52,978

Family allowance (Allocation Familiale AF):

All households with two or more dependent children are eligible to this transfer, independent of income and wealth. The amount of the allowance changes with the age of children. In order to reduce the computational burden, we estimate a weighted average over different ages, which is equal to 155 euros per family per month.

Mean-tested Young children allowances (Plan d'Accompagnement du Jeune Enfant PAJE):

We consider the version of the programme (PAJE) that replaced the old APJE (Allocation pour jeunes enfants APJE) since 2004. Are eligible for this mean-tested programme families with children under 3, whose annual income is below specific income thresholds. Maximum family income (corresponding to the net taxable income) thresholds are different for lone parents, couples with one revenue, couples with two revenues and depend also on the number of dependent children (Table B1). Under the assumptions of our model, all children are dependent according to the French legislation, as long as they live with their parents. The monthly amount per family (not per child, excepted for multiple births) is 184.62 euros for our reference year. Since in our model one period corresponds to 5 years, whereas the benefit is paid only for the first three years of the child, the amount per period is adjusted accordingly.

Baby bonus:

The eligibility conditions related to income are the same as for the PAJE (see previous paragraph and Table B1). This is a single payment made in the year of birth of the child. The amount is 923.08 euros in the reference year.

Mean-tested education related family benefit (Allocation de rentreée scolaire ARS):

This benefit is mean-tested and it is paid for each child aged between 6 and 18 who is attending school. The yearly amount of the benefit depends on the age of the child. Again, to reduce computational time we average amounts over child ages. This leads to a weighted average of 378.12 per child for this transfer.

B.1.4 Health care expenditure

The healthcare expenditure age profile resulting from the estimation procedure describe in Section 3.4 is shown in Figure A2. In terms of funding, there exist a specific social contribution targeted to healthcare. This is mainly paid by employers with a rate of 12.8%.

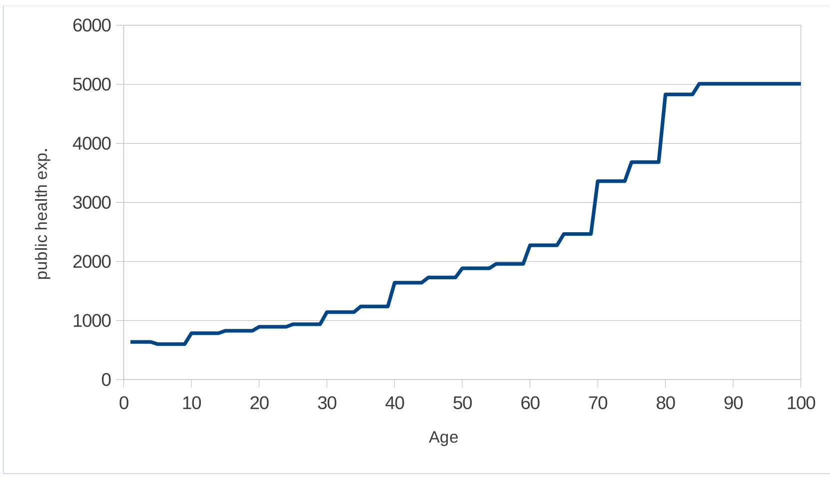

Figure A2: Public health expenditure by age: France

B.1.5 Public childcare

Given that labour supply is endogenous in our model, the cost of childcare is a crucial dimension, because people with children must either buy it in the market or reduce labour supply to look after their children. In most countries it is either the public sector that directly produces childcare, or the purchase by parents of private services may be subsidized. In the case of public provision, a co-payment may be required to parents, whose size may depend on income and/or wealth. In order to model public intervention in the same way in all countries, we estimate an average cost per hour of childcare (see Section 3.4) and calibrate the allowance provided by the public sector (τ_d) so that the overall amount of public expenditure over GDP matches OECD data (OECD (2013)). The calibrated value of τ_d is 76% for France.

B.1.6 Personal income tax

A major peculiarity of the French system of personal income taxation is the household as tax unit. This makes France a particularly interesting comparator for our household model, given that in both Italy and Sweden the individual is the tax unit. Table B2 shows the personal income tax schedule.

Band	income bracket	Marginal Tax Rate
1	0 - 5,963	0%
2	5,963 - 11,896	5.5%
3	11,896 - 26,420	14%
4	26,420 - 70,830	30%
5	70,830 - 150,000	41%
6	>150,000	45%

Table B2: Personal income tax brackets: Italy

This taxation programme has been implemented by defining a tax function, which allows to take all dimensions of heterogeneity accounted for in the model, in addition to income, into account. However, as usual, some simplification were required. First, the French personal income tax system allows for an option to choose between having capital income taxed separately or not. Since, as will be explained below, we use the implicit tax rate, i.e. a comprehensive measure that includes also the revenue raised through personal income taxation, to estimate the burden of capital income taxation, including capital income in the tax base of personal income taxation would lead to double-counting. For the same reason, we exclude tax credits related to childcare expenditure, since the OECD data employed for the calibration include this component. Finally, the presence of a single consumption good in the model means that we cannot account for tax credits related to specific expenditures.

Figure A3 shows average tax rates as a function of household income for different types of families relevant to our model. The Figure shows at least two interesting properties. Fist, as a result of the family being the tax unit, the tax burden of families with the same taxable income is the same no matter whether there is only one or two earners. Second, average tax rates may be negative for low levels of income. This is the result of the introduction of PPE (*Prime Pour l'Emploi*), as an incentive to labour supply by low income workers.

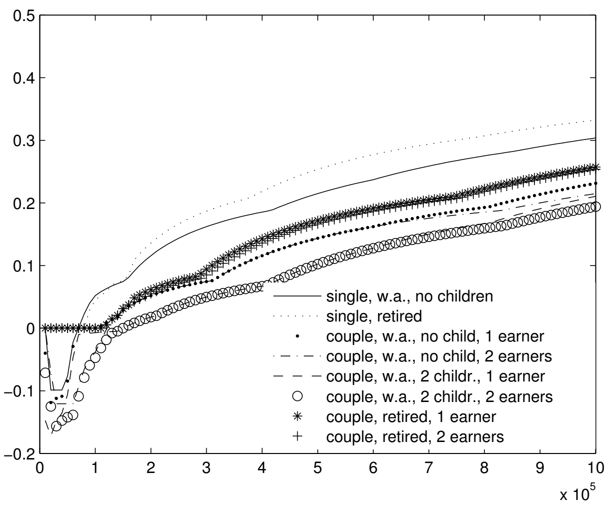

Figure A3: Average personal income tax rate as a function of household income: France. For two earners units it is assumed that income is equally split.

B.1.7 Capital income tax

In our model, taxation of capital is only relevant for the return on savings. In order to characterize capital income taxation through a single parameter, we refer to the implicit tax rate on 'capital & business income', as reported in Eurostat (2014). The same source is also used for the other countries. This implicit tax rate was 25.7% for France in 2012.[25].

[25]2012 is the last year for which data are available in Eurostat (2014)

B.1.8 Consumption tax

We use the "implicit tax rate on consumption" (Eurostat 2014) to characterize consumption taxation in the model. The rate is 25.7% for France.

B.2 Italy

B.2.1 Pension system

The Italian Pension system is divided into three pillars:

1. The first pillar is a public mandatory PAYGO pension system with similar rules applying to both public and private sector employees.

2. The second pillar is voluntary and privately managed and is based on several "collective" agreements ("closed" pension funds), or, alternatively on "open" private pension funds. The latter are managed by banks, insurance companies, and savings management companies. At present the "closed" pension funds are the core of this second pillar of the Italian pension system.

3. The third pillar is private and voluntary and is based on personal pension plans offered by insurance companies and other financial intermediaries. These are essentially standard long-term financial instruments that can be subscribed independently of the individual employment position.

As for France and Sweden, we only model the mandatory component of the pension system.

Old-Age Pension (Pensioni di Vecchiaia):

The PAYGO system underwent a substantial reform in 1995 when the new *notional defined contribution* (NDC) scheme replaced the existing earnings-related method.[26] The system is financed through social contributions. The contribution rate for dependent workers is 33% (in private sector 9.19% is due by employees and 23.81% by employers, in public sector respectively 8.8% and 24.2%). There is a threshold for the annual earned income above which social contributions are not due (99,034 euros in the reference year). The daily social contributions have to be calculated on a minimum daily earned income (equal to 47.07 euros in 2013).

[26] The reform was designed with a very long transition period and fully applied only to workers who were first employed since January 1996.

In the NDC scheme, the minimum contributory period to be entitled to old age pensions is 20 years (reduced to 5 years if the worker retires at the age of 70) and the annual pension benefit is defined as the product of social contributions paid, capitalized using a rate equal to the 5 year moving average of nominal GDP variations, time a transformation factor (the same for man and woman and automatically linked to changes in life expectancy). The latter is meant to ensure the equality between the capitalized value of the social contributions at the time of retirement and the expected present value of pension benefits received during the remaining years of life. In the model, we define the pension benefit by applying the same formula that is used according to the legislation. In Italy there is a survivor's benefit and we include the possibility of receiving this payment in our model. The benefit equals to 60% of the deceased spouse's pension (applicable to both men and women) if the spouse has an income below a certain threshold. For incomes above that amount, the percentage of benefit paid to the survivors decreases. Between 2010 and 2012 retirement age was increased from 60 to 65. In 2018 the standard retirement age will be of 66 years and 7 months. Earlier retirement is possible if the age is at leas 63 and contributions have been paid for 42 years and 5 months. As for France, we consider a fixed retirement age and set it at 65.

B.2.2 Low income support

Social allowance for the elderly:
There is no universal income support in Italy, except for a social benefit scheme (the so-called *assegno sociale*) limited only to people aged 65 and over without any income source or an income less than the social allowance. Eligible individuals receive the total benefit amount only if their income is zero. Otherwise, they receive the difference between the benefit amount and their income. No benefit is due if the income exceeds the fixed threshold (defined on the family status). Monthly increase is granted when specific income, age and contributory conditions apply. In 2013 the base amount of this benefit equals to 442.30 euros per month for persons with zero income.

B.2.3 Family benefits

Family Benefits (Assegni al nucleo familiare)

The Family Benefit is a mean-tested transfer targeted to families of employees and retired individuals. The transfer is decreasing with income according to piece-wise linear schedule and becomes zero above some income thresholds. Other characteristics of the household, including the number of members also matter. For families in working age, the presence of children is a necessary condition to receive the transfer. The mean-tested characterization of this programme implies that in Italy, unlike in France and Sweden, there exists no universal transfer made to families with children.

B.2.4 Health care expenditure

We adopt the same approach and the same data described above for France to estimate the age profile for total as well as public health care expenditure. Figure A4 illustrates the public health expenditure age profile for Italy. In Italy, healthcare expenditure is essentially funded through general taxation.

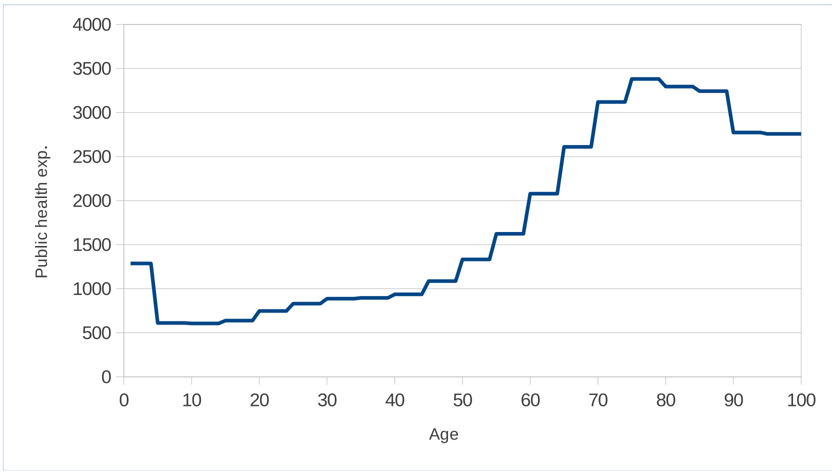

Figure A4: Public health expenditure by age: Italy

B.2.5 Public childcare

We use the same approach as for France (see Section B.1.5) to estimate the public subsidy to childcare purchase for Italy. The calibrated value of τ_d is 50%.

B.2.6 Personal income tax (Imposta sui redditi delle persone fisiche IRPEF)

IRPEF is an individual and progressive tax on total gross income. Although, unlike in France, it is the individual income that is taxed, tax credits also

Band	Income bracket	Tax rate
1	up to 15,000 euro	23%
2	15,001 - 28,000	27%
3	28,001 - 55,000	38%
4	55,001 - 75,000	41%
5	over 75,000	43%

Table B3: Personal income tax brackets: Italy

depend on the family structure (number of dependent children and number of earners).

Personal income taxation is graduated, with progressively higher marginal tax rates applying to higher income brackets. The tax schedule for the reference year is described in Table B3.

Tax rates reported in Table B3 are increased by a regional surcharge which varies across regions. They may also be increased by a local surcharge varying between 0% and 0.5% depending on the municipality. We only take the regional surcharge into account, but we necessarily refer to a single rate, which is estimated by taking the average of tax rates applied by different Regions, weighted by the population (1.68%). The municipal component is ignored, due to the lower rate and the practical difficulty implied by the very large number of Municipalities potentially involved.

All tax credits are non refundable. Hence, unlike in France, the tax liability cannot be negative. Tax credits can be classified into 4 types: tax credits for personal expenses, tax credits with incentive purposes, tax credits for income source (employment income, pension income, self-employment income) and tax credits for dependent family members (i.e. members whose income is less than 2,840 euros). Only the last two types of tax credits are modelled. Both are decreasing in income and are cancelled above a certain income threshold.

B.2.7 Capital income tax

The implicit tax rate on 'capital & business income' is 26.5% for Italy in 2012.

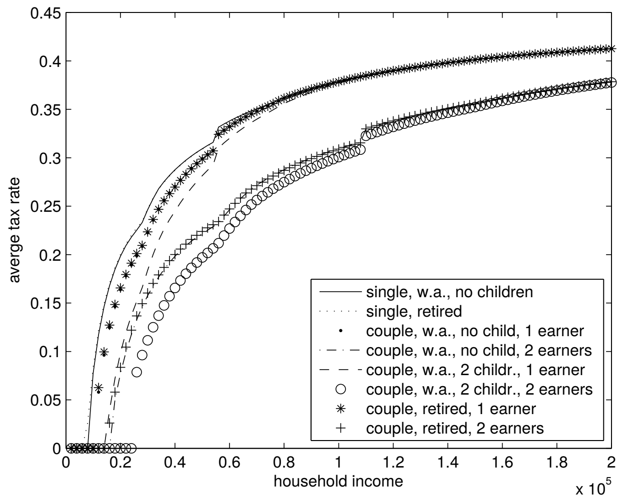

Figure A5: Average personal income tax rate as a function of household income: Italy. For two earners units it is assumed that income is equally split.

B.2.8 Consumption tax

The implicit tax rate on consumption is 17.7% for Italy in 2012.

B.3 Sweden

B.3.1 Pension system

The Swedish pension system is based on three pillars:

1. The first pillar is mandatory, with the same rules applying both for public and private sector employees. The first pillar is in turn made up of three parts:

   (a) income pension (inkomstpension);

   (b) premium pension (premiepension);

   (c) guaranteed pension (garantipension).

2. The second pillar is based on collective agreements, and it has therefore different characteristics for different types of employment (e.g. white *vs.* blue collars). Although most of Swedish workers are involved in these collective agreements, the programme is not mandatory.

3. The third pillar consists of a subsidized private pension with tax-deductible payments.

As for the other countries, we only model the mandatory component of public pension systems. Hence, we model parts (a) and (c) of the first pillar, and, more precisely, the rules introduced with the 1994 reform. These rules will be fully in operation for younger cohorts (pension benefits entirely calculated according to the new rules will not start to be paid until 2018), whereas most of the pension benefits which are currently paid are based either entirely on the old system, or on a mix of the old and the new.

Social contributions:

The burden of social contributions is split in the following way between employees and employers:[27]

- Employees pay the 7% for annual gross income between 2,176 euros[28]. and 52,796 euros;

- The social contribution base for employers is the same as for employees (gross income), whereas the contribution rate is 10.21%. For employers, however, contributions are also due above the 52,796 euros threshold. Since the part exceeding this provides no pension credit, it can be actually interpreted as a tax.

The total amount of pension related social contributions paid is split in the following way:

- 86% goes to the income pension (inkomstpension). The employee cannot decide on the destination of this part;

- 14% goes to "premimum pension" (premiepension). In this case, the employee is free to choose among several privately managed financial account schemes with different risk-return profiles. As previously stated, we do not model this component of the pension system.

The following paragraphs describe the characteristics of the three components of the pension system.

[27]Here we describe only the part of social contributions related to pensions. In Sweden, social contributions also finance other public sector interventions, such as health care, occupational injuries and parental insurance.

[28]The exchange rate we use is 8.6515 (source: European Central Bank; see https://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-sek.en.html)

The income pension (inkomstpension):

This part of the pension system is based on a pay-as-you-go *notional defined contribution* scheme. This component of the Swedish pension system shares several characteristics with the Italian one, which was described in Section B.2.1.

The return on contributions related to this part of the pension system corresponds to the per-capita wage growth rate.[29]

At retirement, the pension benefit is calculated by applying a coefficient to the value of accumulated social contributions. The coefficient is the same for men and women, but depends on age and life expectancy. In the model, we define this coefficient so that the equality between the value of social contributions at the time of retirement and the expected present value of pension benefits received during the remaining years of life is ensured.

The guaranteed pension (garantipension):

For individuals with no or low earnings related benefits, the system provides a guaranteed benefit to ensure a minimum standard of living in retirement. The guaranteed benefit is means-tested against public pension income and it is payable from age 65. The maximum guaranteed pension (for those who do not have other income sources) is:

- 10,956 euros per year for a single pensioner;
- 9,773 euros per year if married.

The amount of the transfer is defined so that there is a 100% offset up to 6,481 euros and 5,864 euros, respectively for singles and married individuals. The offset is reduced to 48% for a single individual with income between 6,481 euros and 15,791 euros, and for a married individual with income between 5,864 euros and 13,991 euros.[30]

[29] The actual return on contributions paid also depends on two additional components that we do not model. The first is a deduction for administrative costs that we ignore because of its small size (0.1% on average in 2011). The second is an increase in pension rights related to the redistribution of contributions paid by workers who die before reaching pension age. Ignoring this is consistent with one of the assumptions that are introduced to reduce the computational burden, namely a survival probability equal to 1 throughout working age.

[30] According to the available data, the fraction of pensioners receiving some transfer is very large (46% in 2010).

B.3.2 Low income support

Social assistance:

This benefit is a minimum income. It can be paid if the family has temporary financial problems, of it the disposable monthly income is too low. Other eligibility conditions include having no wealth and being willing to take a job if offered. The income test is based on the cost of a standard set of basic commodities. This minimum standard is adjusted to account for the age of children, family status and size. In 2013, the monthly amount equals 448 euros for singles and 765 euros for couples.

B.3.3 Family benefits

We model the child benefit (Barnbidrag) that is paid monthly for each child until 16 years (increased to 20 if the child studies in upper secondary school; in this case it is only paid for 10 months a year). The monthly amount is 109 euros per child. An extra amount is paid starting from the second child, and it is increasing with the number of children (it starts with only 10 euros per month for the second child and reaches 109 euros per month if the number of children is 5 or more).

B.3.4 Health care expenditure

The same approach and the same data that were described above for France have been also adopted to estimate the age profile for total as well as public health care expenditure for Sweden. Healthcare expenditure is partly funded by social contributions (4.35% on the component paid by employers). The age profile of expenditure is shown in Figure A6.

B.3.5 Public childcare

We use the same approach as for France (see Section B.1.5) and Italy to estimate the public subsidy to childcare purchase for Sweden. The calibrated value of τ_d is 91%.

B.3.6 Personal income tax

Sweden has a purely individual personal income tax system. Hence, in this respect, the system is different from both the French, where the family is the tax unit, and the Italian, where the tax debt also depends on family size

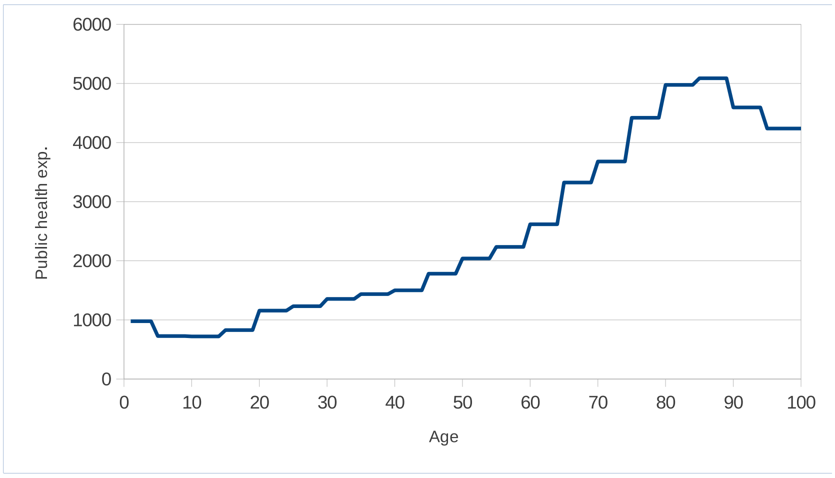

Figure A6: Public health expenditure by age: Sweden

and other characteristics (e.g. dependent vs. non dependent partner). The system is pretty simple, the main characteristics being:

- The tax base is defined as the difference between taxable income and two types of allowance: basic allowance and allowance for voluntary private pension. Since we do not explicitly model voluntary private pensions, we consider only the former. The basic allowance, which varies with income, contributes to the progressivity of the tax system.

- Personal income taxation has both a central and a substantial local component. The former is based on three tax rates that apply on the corresponding income bands according to Table B4.

Band	Income bracket (€)	Tax rate
1	0- 47,760	0%
2	47,760 - 68,631	20%
3	68,632	25%

Table B4: Government personal income tax schedule: Sweden

Local tax rates share the same tax base as the government component, but are defined at the Municipality level. Although we follow the general rule of not modelling purely local programmes, ignoring this component of the Swedish tax system would introduce a large bias, due to its size.[31] Therefore, we refer to the average tax rate across municipalities, as reported in Klas (2014). This amounts to 32.01%, and it is split between "municipality tax" (20.62%), "County council tax" (11.17%) and "funeral tax" (0.22%).

- There are ten different types of tax credit, which are non-refundable. Most of these refer to specific types of expenditure that we are unable to model (e.g. broadband connections, domestic and reconstruction services). We only model the "earned income tax credit". This depends on income and on whether the individual is younger or older than 65.

The combination of the characteristics of the personal income tax system with our modelling assumptions leads to a simple taxation scheme (Figure A7).

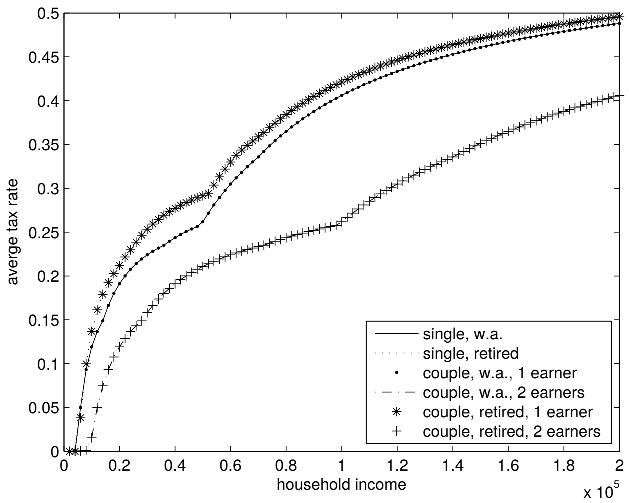

Figure A7: Average personal income tax rate as a function of household income: Sweden. For two earners units it is assumed that income is equally split.

B.3.7 Capital income tax

As for the other countries, the implicit tax rate on 'capital & business income' (Eurostat, 2014) is assumed for the taxation of returns on savings. The rate is 23.2% in the reference year.

[31]Note that the most important local component of personal income tax, i.e. the regional surcharge, is also modelled for Italy.

B.3.8 Consumption tax

The Swedish "implicit tax rate on consumption" is 26.5% (Eurostat, 2014).

C List of variables

Symbol	Definition
J^R	Retirement age
$\overline{J}$	Maximum age
h^g	Education level for gender g
k_j	N. children at age j
$\psi_j(g)$	Probability of surviving up to age j for gender g
q	Household consumption
c_j	Individual consumption at age j
l_j	Labor supply at age j
z_j	Leisure at age j
d_j	Demand for day care services at age j
a_j	Assets at age j
TR	Lump-sum transfer from the government
r	Interest rate
τ_r	Tax rate on capital income
τ_q	Tax rate on consumption
τ_d	Subsidy to purchase of day care services
y_j^g	Income at age j for gender g
$e_{j,h}^g$	Efficiency unit at age j for gender g and education h
ζ_j	Value of the idiosyncratic productivity shock
sc_j^g	Social contributions at age j for gender g
hs_j^g	Public health expenditure at age j for gender g
$\overline{hs}_j^g$	Minimum health expenditure at age j for gender g
sb_j^g	Accumulated pension rights at age j for gender g
p_d	Price of day care services
$t_{y,j}$	Personal income tax at age j
$tr_{k,j}$	Child subsidy at age j
$tr_{y,j}$	Income support transfer at age j