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On the effects of public and private transfers on capital accumulation: some lessons from the NTA aggregates

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Abstract Intergenerational transfers are a very important part of our daily economic activity. These transfers, whether familial or public, may influence our economic decisions to the same extent that financial markets do. In this paper, we seek to shed some light on the effects of transfers on capital accumulation in the face of demographic aging. In particular, a general equilibrium overlapping generations model with realistic public and familial

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transfers drawn from the National Transfer Accounts project is implemented to Spain. Given that, in this case, net familial transfers mainly go from parents to children while public transfers go from children to parents, it is shown that the Spanish baby boom and baby bust could lead to capital depletion and a reduction in consumption per capita.

Keywords Second demographic dividend · Transfers · Computable general equilibrium

JEL Classification D58 · J11 · H53

1 Introduction

The Spanish economy faces one of the most dramatic population aging processes of all the developed countries. According to Eurostat population projections, the old-age dependency ratio in Spain will go from 24.55% in year 2007 to 65% in year 2050. As in most developed countries, the major concern is whether the sharp increase in this ratio will necessarily be burdensome for future workers. The answer to this question depends to a great extent on the way the dependent sides of the life cycle (childhood and elderly) are financed. In contrast to dependent children, retirees may finance their consumption with their own capital. Hence, the increasing number of retirees with savings, followed by smaller cohorts of workers, may lead to capital deepening, which is also known in the literature as *second demographic dividend* (Mason and Lee 2006).[1] As a result, workers are able to finance retirement benefits more easily since they become more productive, even when human capital investments remain unchanged. However, unless the necessary incentives for accumulating capital are in place, a permanent second demographic dividend is not guaranteed.

Mainly in response to the decline in saving rate after the postwar period in the USA, the literature has studied extensively the mechanisms for stimulating the accumulation of capital (Gokhale et al. 1996). We know from this literature that population aging, which is the combined result of mortality reduction for old-age groups followed by a decrease in fertility, could, a priori, lead to a greater capital accumulation. Indeed, assuming the retirement age remains constant, increases in life expectancy after retirement should boost the motivation to save for retirement, while smaller family sizes should reduce overall childrearing costs to parents, thereby increasing the ability to save.

[1]The term demographic dividend has been used in economic demography literature, and it is full of economic meaning. The first dividend refers to the positive initial effect of a demographic transition on consumption per capita: the so called support ratio of workers to consumers increases in the first stages of the demographic transition (Bloom and Williamson 1998). This effect always occurs and is temporary—it disappears as those workers age. In contrast, the second demographic dividend, called capital deepening in economic terms, is not automatic and might be persistent.

Nevertheless, nonmarket transfers might either increase or decrease savings, boosting, or offsetting the positive economic effects of population aging. The net effect depends on the difference between the size of the transfers individuals will receive and how much they will have to pay over the course of their remaining lifespan (Willis 1988), or, equivalently, how much wealth individuals will need to satisfy their consumption needs relative to the existing stock of capital (Lee 1994; Bommier and Lee 2003). If individuals expect to receive more (less) transfers than they give during their lifetimes, they will deplete (accumulate) capital. For this reason, models that do not introduce transfers might lead to misleading results (Kotlikoff and Summers 1981).

In order to explain the accumulation of capital over time, it is therefore critical to specify current and future population characteristics, market transfers, and nonmarket public and private transfers. The National Transfer Accounts Project (NTA) has recently made available estimates of market and nonmarket interage flows. In particular, it measures economic flows across age groups, including public and private transfers to both sides of the dependent life cycle, which are consistent with National Income and Product Accounts (NIPA).[2] A previous attempt to derive age-specific information was made in generational accounting, which was developed to assess the fiscal burden that current generations are placing on future generations (Auerbach et al. 1991). Generational accounting provides information on intergenerational public transfers, but it lacks information on familial transfers, which is crucial for understanding the accumulation of savings.

In this paper, we develop a general equilibrium overlapping generations model (OLG) with realistic demography (Bommier and Lee 2003) and realistic transfers drawn from the NTA data set. With this analysis, we aim to shed light, from the empirical perspective, on the interaction between intergenerational transfers and capital accumulation. The present study is the first general equilibrium OLG model that uses the NTA data. To take advantage of all the rich demographic information by single years of age, we have realistically modeled the Spanish demography. The calibration procedure has been developed so as to simultaneously target the NTA age profiles, the main Spanish macroeconomic statistics, and the Spanish government budget in year 2000.[3] This paper differs from other general equilibrium OLG models applied to the Spanish economy in that we introduce the whole set of familial and public transfers by age in a realistic fashion (Ríos-Rull 2001; Rojas 2005; Díaz-Giménez and Díaz-Saavedra 2009; Sanchez-Martin 2010).[4]

[2]National Transfer Account database (NTA), http://www.ntaccounts.org.

[3]The calibration procedure is shown in Appendix A.1 in Supplementary material.

[4]As detailed in the demography section in the online material, we deviate from many of the available large-scale OLG models for Spain and other countries (Börsch-Supan et al. 2006) in that our economy is in steady state in 1870 rather than in 1960, capturing most of the Spanish demographic transition features.

In line with previous literature, we show that under the current welfare state and average retirement age, population aging could lead to serious tax adjustments. In particular, taking payroll taxes as the adjusting policy variable, we estimate that net wages start decreasing in 2030. Strikingly, we find that aggregate consumption and the stock of capital in effective units of labor would increase significantly up to 2048 and 2040, respectively. However, this positive economic scenario would be temporary. Indeed, the additional accumulation of effective capital would be depleted: First, because baby boomers would save less due to the generous pensions they could expect to receive relative to what they had contributed; second, because the baby bust generation would consume more since they would not have an incentive to save, given the large amounts of inter vivos transfers that they expected to receive from their parents.

The remainder of the paper is divided into four parts. Given the novelty of the NTA database and the peculiarities of its accounting strategy, we devote Section 2 to introducing the NTA methodology in an overlapping generations setup. Section 3 shows the specific features of the model. Section 4 presents our simulation results for the Spanish economy and Section 5 gives some final remarks.

2 OLG meets NTA

The overlapping generations model developed by Samuelson (1958) and Diamond (1965) is currently the theoretical workhorse for analyzing the intergenerational trading of goods and services. Its microfoundation lies in the life cycle theory of saving, and the model enables us to examine outcomes by age in both a cross-sectional and a longitudinal fashion. In building this simulation model, we make use of the standard Samuelson–Diamond model, and we introduce the necessary arrangements for transforming the flow budget constraint, which is frequently used in the OLG models, into the NTA flow identity.[5]

2.1 The NTA accounting strategy

In general, children and retirees consume more than they produce, whereas production is higher than consumption at prime working ages. The surplus generated by workers is partly stored in the financial sector as a buffer stock; partly levied by the government to provide goods, services, and benefits;

[5]See Willis (1988) for a first attempt to include exogenous family transfers in the OLG framework. See also Lee (1994) for an application estimating the size of transfer and real wealth in the USA.

and partly transferred within and outside the household to support the consumption of other age groups. In order to illustrate explicitly these life-cycle decisions, NTA rearranges the basic national accounting identity into four accounting items: (a) the *life-cycle deficit* (LCD), (b) the *asset-based reallocation* (ABR), (c) *public transfers* (TG), and (d) *familial transfers* (TF). The NTA fundamental equation at age x is then given as follows:

$$\text{LCD}_x = \text{ABR}_x + \text{TG}_x + \text{TF}_x, \text{ for all } x. \tag{1}$$

Each accounting item represents a flow variable, where positive (negative) values are associated to net recipients (givers). First, LCD measures the difference between (public and private) goods and services consumed, and gross labor income by age.[6] Thus, a cohort who produces more (less) than they consume will have a negative (positive) LCD. Second, transfers are divided into public and private: TG stands for public and TF for private net transfers received directly or indirectly by individuals.[7] Since total transfers given (outflow) equals total transfers received (inflow), at an aggregate level in a closed economy, both public and private transfers must net to zero.[8] Third, ABR measures the use of financial and real assets to finance current and future LCDs, which is equal to asset income less savings. Asset income can be decomposed into the interest gained by those who survived up to the end of the period and that of those who died during the period.[9]

An important feature of the NTA accounting framework is that it is consistent with *national income and product accounts*. Indeed, assuming a closed economy, the sum across age of the life-cycle deficit gives

$$\underbrace{\sum_x \text{LCD}_x N_{x+1}}_{C+G-\omega AL} = \underbrace{\sum_x \text{ABR}_x N_{x+1}}_{rK-S} + \underbrace{\sum_x (\text{TG}_x + \text{TF}_x) N_{x+1}}_{0}, \tag{2}$$

which, by rearranging the terms, is equal to the market-clearing condition

$$C + G + S = rK + \omega AL. \tag{3}$$

where C and G are aggregate private and public consumption, S is the aggregate net savings, r is the (real) return of capital, K is the stock of physical

[6]This definition of life-cycle deficit differs from that of Kotlikoff and Summers (1981). Recall that, by estimating savings from lifetime income and (only) private consumption data, the authors indirectly measured the relevance of intergenerational transfers on capital accumulation; see Lee (1994).

[7]As NTA assumes the individual is the fundamental unit, net transfers received by firms from the government are also imputed to individuals.

[8]In an open economy, the sum of all private transfers is equal to the value of net transfers with the rest of the world.

[9]Current estimates of NTA profiles do not explicitly report bequests given. As a consequence, the ABR profile implicitly includes bequests received (h). This fact implies that if the amount of bequests is sizable, ABR will be higher than expected at younger ages.

capital, ω is the marginal product of effective labor, A is the technological progress, and L is the total units of labor.

2.2 Life-cycle wealth using NTA

According to the life-cycle model, asset holdings at any given age is the present value of the remaining lifetime expenditures, less the present value of the remaining lifetime income (including transfers). Total wealth, or life-cycle wealth, at any given age is, by contrast, the present value of the remaining lifetime of own consumption (public and private), less the present value of the remaining marginal product of labor.[10] Both magnitudes are easily formulated in Eqs. 4 and 5 using the NTA framework:

$$a_x = \sum_{s \geq x} \mathrm{ABR}_s \prod_{z=x}^{s} \frac{p_z}{1+r}, \tag{4}$$

$$w_x = \sum_{s \geq x} \mathrm{LCD}_s \prod_{z=x}^{s} \frac{p_z}{1+r}, \tag{5}$$

where p_z is the conditional survival probability at age z. Note that the discount factor naturally arises from discounting the NTA flow budget constraints of the cohort. Equation 5 is related to Eq. 4 using the NTA identity Eq. 1 as follows:

$$w_x = a_x + \sum_{s \geq x} (\mathrm{TG}_s + \mathrm{TF}_s) \prod_{z=x}^{s} \frac{p_z}{1+r} = a_x + t_x. \tag{6}$$

where t_x is the transfer wealth or the present value, evaluated at age x, of the remaining lifetime public and familial transfers.

At an aggregate level, total wealth can be obtained by multiplying w_x by the number of people at each age. Summing Eq. 6 across age gives the aggregate total wealth,

$$W = \sum_x w_x N_x = \sum_x a_x N_x + \sum_x t_x N_x = K + T, \tag{7}$$

where K is the aggregate supply of capital by households and T is the aggregate transfer wealth.[11] As a particular case, we have that K is the stock of physical capital if, and only if, the economy is closed; otherwise, K will be asset holdings by people in the country.

[10] It should be noted from the definition of LCD that the NTA framework introduces public consumption explicitly into the flow budget constraint, as seen in Eq. 14 in Section 3.1.

[11] For the definition of T and K, we follow that of Willis (1988), Lee (1994), and Bommier and Lee (2003).

The comparison between the aggregate asset holdings (K) and the aggregate total wealth (W) gives us insight into the excess, or deficit, of aggregate lifetime consumption over financial capital and the present value, survival weighted, of the stream of gross salaries.[12] If W is greater than K, the current population are on average, net receivers of transfers ($T > 0$), which allow them to have a higher rate of consumption, assuming the stock of capital remains the same. The opposite is also true when $T < 0$. Whether T is equal to, greater than, or lower than zero depends upon both demographics and institutional arrangements.

3 The model economy

In this section, we present the model economy used to estimate the total wealth and aggregate asset holdings in Spain. All the information on the Spanish life-cycle deficit, asset-based reallocation, and public and private transfers is taken from the NTA for Spain for the year 2000. These age profiles provide us with insight into how Spanish households reallocate their earnings across different age groups. In order to estimate the asset holdings, total wealth, and transfer wealth in any year t, we would need the LCD, ABR, TG, and TF by age from year t until all living cohorts in that year have died. However, only estimates for the year 2000 are available. There are two main approaches for tackling this problem. The first is by using "economic" *synthetic cohorts*, where NTA age profiles remain unchanged over time (Lee and Mason 2010; Patxot et al. 2011; Bixby and Robles 2008). This methodology provides useful but restrictive information, in the sense that individuals do not change their saving behavior with changes in prices. This drawback is addressed using a general equilibrium OLG model, which is the methodology applied in this paper. A third possibility is to use a partial equilibrium model or a mixture of the above-mentioned techniques. Although partial equilibrium is not as restrictive as the synthetic cohort technique, changes in aggregate savings do not affect factor prices, which leads to an overestimation of both positive and negative effects.

[12]Total wealth by an individual at age x equals the present value, survival weighted, of the stream of public and private consumption less gross labor income. Let the present value of consumption and gross labor income be denoted by $\tilde{c}$ and $\tilde{H}_x$. Then, the intertemporal budget constraint is given by the following:

$$w_x = \tilde{c}_x - \tilde{H}_x = a_x + t_x \Rightarrow \tilde{c}_x = \tilde{H}_x + a_x + t_x. \quad (8)$$

Thus, for $\tilde{c}_x > (<) \tilde{H}_x + a_x$ it is necessary that $t_x > (<) 0$.

Our economy is comprised of public and private sectors, which in turn consist of a government, one neoclassical firm, and a finite number of domestic units. The economy is assumed to be closed to foreign capital investments, but not to foreign labor. Each economic unit will be represented by a set of flows, which are summarized in Table 1. See an extended version, including data sources, in Appendix A.2 in Supplementary material.

3.1 The domestic economic unit

Each domestic unit is assumed to be comprised of one adult and a number of dependent children. Individuals face mortality risk. A new economic unit is assumed to be set up when an individual is 21 years old (T_w), the age at which children become adults and start making decisions in our model. However, when an adult dies, the economic unit vanishes. From that moment onwards, her/his surviving dependent children (orphans) will be borne by a different household with similar characteristics. To compensate for the additional burden, the new household receives the asset holdings from the adult.

We assume that there is no annuity market and that our individuals do not save with a bequest motive in mind. Thus, individuals may leave an accidental bequests at death (Yaari 1965, Case A). In line with that of Lee et al. (2000) and Braun et al. (2009), we assume that adults make decisions for their own well-being, as well as for the well-being of their dependent children, i.e., the utility of raising children is proportional to their consumption. We also assume that all household heads have identical additive instantaneous preferences denoted by u (with $u' > 0$ and $u'' < 0$). The optimal consumption decision of

Table 1 Modeled national transfer accounts by flow and economic agent

	Individual	Government	Firm
Inflows	Salary	Progressive income tax	Revenues
	Asset income	Indirect tax	
	Familial transfers	Corporate tax	
	Public consumption	Payroll tax	
	Public benefits		
	Bequests		
Outflows	Consumption	Pensions benefits	Salaries
	Childrearing	Widowhood benefits	Asset income
	Familial transfers	Maternity benefits	Corporate tax
	Taxes	Public health	Net investment
	Saving	Public education	
	Bequests	Public others	

the household heads at age $x \in \{T_w, \ldots, \Omega - 1\}$ are described by the following Bellman equation:[13]

$$V_{t,x}(a_{t,x}) = \max_{c_{t,x}} \left\{ \lambda_{t,x} u(c_{t,x}) + \beta p_{t,x} V_{t+1,x+1}(a_{t+1,x+1}) \right\}, \tag{12}$$

where Ω is the maximum longevity, u is represented by a CRRA utility function, $\beta \in (0, 1]$ is the subjective discount factor, $p_{t,x}$ is the probability of surviving from age x to age $x+1$ in year t, $\lambda_{t,x}$ is the number of equivalent adult consumers within an economic unit whose head is x years old, $c_{t,x}$ is the consumption of private goods and services of the head of the economic unit, and $a_{t,x}$ denotes assets held at age x in year t. λ is calibrated to reproduce the NTA age profiles for private consumption (see Section A.1.3 in the Appendix of Supplementary material).

Note that along the simulation, we are assuming that the transfer structure is kept constant to some extent, while some changes will still occur. For example, the share of resources transferred from parents to dependent children (λ) is fixed to the value observed in the 2000 NTA profiles, while the total amount of resources will vary because of changes in the number of children and in the level of consumption of the household head. The situation is similar with interhousehold transfers. See the Appendix in Supplementary material for details in the calibration process in each case.

Assuming constant transfer structure is indeed a strong simplification that can be justified because only a set of cross-sectional NTA profiles is available at the moment. Besides, from the theoretical point of view, it is worth

[13] An alternative approach could be to maximize the expected utility of the adult in the household (Tobin 1967; Deaton and Muellbauer 1980; Ríos-Rull 2001). To illustrate this point, let us assume the following standard household problem:

$$V_x(a_x) = \max_{c_x} \{u(c_x/\lambda_x) + \beta V_{x+1}(a_{x+1})\},$$
$$\text{s.t. } a_{x+1} = (1+r)a_x + y_{l_x} - c_x, \text{ for } x \in \{T_w, \ldots, \Omega - 1\}, \tag{9}$$

where c_x is now the total household consumption with a household head of age x.

Assuming a logarithmic instantaneous utility function and substituting the flow budget constraint into the Bellman equation

$$V_x(a_x) = \max_{a_{x+1}} \left\{ \log\left(\frac{(1+r)a_x - a_{x+1} + y_{l_x}}{\lambda_x} \right) + \beta V_{x+1}(a_{x+1}) \right\}. \tag{10}$$

Differentiating with respect to a_{x+1} and using the envelope theorem gives the Euler equation

$$c_{x+1} = c_x \beta(1+r). \tag{11}$$

Equation 11 implies that household saving does not change over the lifespan for a constant household labor income stream, even when the number of equivalent adult consumers in the household increases. However, a cross-country comparison of consumption profiles using NTA data suggests that adults smooth consumption at the individual level.

mentioning that the need for government intervention on intergenerational family transfers remains an unanswered question in the literature (Cigno and Luporini 2006). Interestingly, Cigno et al. (2006) find evidence in favor of the existence of a set of family rules influencing individual optimization.[14] In fact, these authors build bridges across the economic and the sociological reasons for private transfers. In the former, transfers are a result of individualistic optimization, either due to altruistic gifts, or to a strategic search of services. On the contrary, Cigno (1993) models the extended family as a group of individuals, who find on their interest to abide a set of fundamental rules, a "family constitution". Individuals then decide first to comply with it and, second, the amount they transfer.

Individuals receive income from three sources. First, the firm compensates its labor force in the form of salaries and pays interest on their assets. The labor force is supplied inelastically only from age 21 (T_w) to age 63 (T_r). The salary by age $y_{l_{t,x}}$ is a function of the marginal product of the effective labor ω_t, the technological progress A_t, the effective labor units supplied ϵ_x, and the probability of being employed at that age $1 - u_{t,x}$. Second, they receive inter vivos transfers from their parents ($\phi^+_{t,x}$) and accidental bequests ($h_{t,x}$) when their parents die. Third, the government provides pension benefits ($b_{t,x}$) if they have a child, become a widow/er, or are retired. To introduce widows/ers, we matched household heads that belong to the same cohort. All pension benefits are assumed to be funded through a PAYG system ($\tau_t^{ss} y_{l_{t,x}}$).

In order to finance public consumption (health, education, and other public expenditures), the government levies taxes on the following market transfers: consumption of private goods and services ($\tau_t^p \lambda_{t,x} c_{t,x}$), personal income ($\tau^i_{t,x}[r^i_{t,x}(a_{t,x} + h_{t,x}) + \sum_{j \in \mathbb{B}} b^j_{t,x} + (1 - \tau_t^{ss}) y_{l_{t,x}}]$), where $\mathbb{B}$ is the set of all public benefits, and corporate profits. Let us denote the consumption of public goods and services at age x in year t by $g_{t,x}$. The disposable income is then used to pay the consumption of the economic unit ($\lambda_{t,x} c_{t,x}$), to transfer income to their adult offspring ($\phi^-_{t,x}$), and to save ($a_{t+1,x+1} - a_{t,x}$).[15] Therefore, the flow budget constraint of an adult at age x in year t is given by

$$\begin{aligned}(1 + \tau_t^p)\lambda_{t,x} c_{t,x} + \phi^-_{t,x} + a_{t+1,x+1} = {} & (1 + r_t(1 - \tau^i_{t,x}))(a_{t,x} + h_{t,x}) \\ & + (1 - \tau^i_{t,x})[(1 - \tau_t^{ss}) y_{l_{t,x}} + \sum_{j \in \mathbb{B}} b^j_{t,x}] + \phi^+_{t,x},\end{aligned} \quad (13)$$

where r_t is the after-corporate tax (real) interest rate. Although Eq. 13 is better for solving the decision problem, in our case it is more convenient to calculate the intertemporal budget constraint, as in NTA. To do so, we first have to

[14] In particular, the effect of credit rationing on the probability of giving transfers is analyzed as a way to discriminate between altruistic and strategic motives for giving transfers and the constitutional model.

[15] The specific formula applied to each transfer has been placed in Appendix A.1 in Supplementary material.

discount the flow budget constraints as if an actuarial note had been purchased; and, second, we have to add all transfers except for those that are directly paid by the firm to the government, such as corporate tax. Thus,

$$\sum_{s=x}^{\Omega-1}\left\{\prod_{z=x}^{s}\frac{p_{t+z-x,z}}{1+r_{t+z-x}}\right\}\left(g_{t+s-x,s}+c_{t+s-x,s}-y_{l_{t+s-x,s}}\right)$$
$$=a_{t,x}+\sum_{s=x}^{\Omega-1}\left\{\prod_{z=x}^{s}\frac{p_{t+z-x,z}}{1+r_{t+z-x}}\right\}\eta_{t+s-x,s}, \qquad (14)$$

where $\eta_{t,x}$ is total (net) nonmarket transfers at age x in year t. Note that, in Eq. 14, the first term on the left-hand side corresponds to the total wealth by the individual and the second term on the right-hand side to transfer wealth by the individual. If we denote the present value, survival weighted, of the stream of gross salaries at age x in year t by $\tilde{H}_{t,x}$ and the transfer wealth at age x in year t by $t_{t,x}$, then we can rewrite Eq. 14 as follows:

$$\sum_{s=x}^{\Omega-1}\left\{\prod_{z=x}^{s}\frac{p_{t+z-x,z}}{1+r_{t+z-x}}\right\}\left(g_{t+s-x,s}+c_{t+s-x,s}\right)-\tilde{H}_{t,x}=a_{t,x}+t_{t,x}. \qquad (15)$$

The optimal consumption of an adult will be given by the usual decision problem. Thus, it can be shown that the first order condition of maximizing Eq. 12 subject to Eq. 13 and the boundary conditions $a_{t,T_w}=0$, $a_{t,x}\geq 0$, for any t, is given by

$$\frac{c^{\sigma}_{t+1,x+1}}{c^{\sigma}_{t,x}}\geq\frac{1+\tau^p_t}{1+\tau^p_{t+1}}\beta p_{t+1,x+1}(1+r_{t+1}(1-\tau^i_{t+1,x+1})), \qquad (16)$$

with equality iff $a_{t,x}>0$.

It is noteworthy that, for a given set of future interest rates, salaries, and demographic characteristics, we can see how consumption at age T_w depends on the transfer system established by substituting Eq. 16 into Eq. 15. Thus, an individual who has negative transfer wealth ($t_{t,x}<0$) would, all other things being equal, consume less over her or his lifespan, which implies a lower total wealth. The opposite is also true with a positive transfer wealth ($t_{t,x}>0$).

3.2 The firm

We model a neoclassical firm using a Cobb–Douglas production function $F(K_t, A_tL_t)=K_t^{\alpha}(A_tL_t)^{1-\alpha}$, where α is the capital share, and K is the capital stock, which under a closed economy is

$$K_t=\sum_{x=T_w}^{\Omega}a_{t,x}N_{t,x}; \qquad (17)$$

and whose law of motion is given by

$$K_{t+1}=K_t(1-\delta)-I_t, \qquad (18)$$

where δ is the capital depreciation rate and I_t is gross investment. A_t is the labor-augmenting technological progress and L is the total units of labor.

$$L_t = \sum_{x=T_w}^{T_r-1} \epsilon_x (1 - u_{t,x}) N_{t+1,x+1}. \tag{19}$$

Following Hassett and Hubbard (2002), after paying corporate taxes, the net cash flow of the firm (without investment tax credit) is given by

$$X_t = (1 - \tau_t^c)(F(K_t, A_t L_t) - \omega_t A_t L_t) - I_t,$$

where τ_t^c is the corporate tax rate.

The firm chooses the sequence $\{K_s, L_s\}_{s=t}^{\infty}$ so as to maximize its individual value at time t, $J_t = \sum_{s=t}^{\infty} X_s \prod_{z=t}^{s} \frac{1}{1+r_z}$. Thus, the optimality conditions at any time t are given by

$$\omega_t A_t = F_L(K_t, A_t L_t), \tag{20}$$

$$r_t + \delta = F_K(K_t, A_t L_t) \cdot (1 - \tau_t^c). \tag{21}$$

3.3 Government

We model a government that has two separate balanced budgets. On the one side, given that the Spanish Social Security administration runs a quasidefined benefit unfunded pension system, we assume that the payroll tax is chosen so as to balance the budget of the pension system,

$$\sum_{x=T_w}^{\Omega-1} \sum_{j \in \mathbb{B}} b_{t,x}^j N_{t+1,x+1} = \tau_t^{ss} \sum_{x=T_w}^{T_r-1} y_{l_{t,x}} N_{t+1,x+1}. \tag{22}$$

On the other side, the government provides public goods and services such as health, education, and others that are financed through personal income taxes, corporate taxes, and taxes on consumption,

$$\begin{aligned} &\sum_{x=0}^{\Omega-1} \sum_{j \in \mathbb{J}} g_{t,x}^j N_{t+1,x+1} \\ &\quad = \tau_t^p \sum_{x=T_w}^{\Omega-1} \lambda_{t,x} c_{t,x} N_{t+1,x+1} + \tau_t^c \frac{r_t + \delta}{1 - \tau_t^c} K_t \\ &\qquad + \sum_{x=T_w}^{\Omega-1} \tau_{t,x}^i \left((1 - \tau_t^{ss}) y_{l_{t,x}} + \sum_{j \in \mathbb{B}} b_{t,x}^j + r_t (a_{t,x} + h_{t,x}) \right) N_{t+1,x+1}, \end{aligned} \tag{23}$$

where $\mathbb{J}$ is the set of public forms consumption.

All tax rates are assumed to be flat, except for the personal income tax rate, which is progressive. This allows us to better measure transfers of wealth and savings since both variables are age-dependent. Unfortunately, by modeling a progressive personal income tax profile with nonrisky assets, we cannot introduce public debt; otherwise, we could not satisfy the *nonarbitrage on assets condition*.[16]

Finally, to guarantee that Eq. 23 is balanced at all times, we assume that any change in aggregate public consumption that is not covered by personal income taxes and corporate income taxes will be financed through indirect taxes.

3.4 Equilibrium

Let $x \in \mathcal{X}$ and $t \in \mathcal{T}$. In this economy, a *competitive equilibrium with transfers* is a list of sequences of quantities $c_{t,x}$, $a_{t,x}$, $N_{t,x}$, A_t, L_t, K_t, prices ω_t, r_t, taxes τ_t^p, τ_{ss}^p, τ_c^p, $\tau_{t,x}^i$, public benefits $\{b_{t,x}^j\}_{j\in\mathbb{B}}$, public consumptions $\{g_{t,x}^j\}_{j\in\mathbb{J}}$, and private transfers $h_{t,x}$, $\phi_{t,x}^-$, $\phi_{t,x}^+$, $(\lambda_{t,x} - 1)c_{t,x}$ such that, at each point in time t:

(a) the firm maximizes its value J_t by choosing K_t and L_t according to Eqs. 20 and 21,
(b) individuals maximize their expected lifetime utility Eq. 12 subject to Eq. 13,
(c) both government budget constraints Eqs. 22 and 23 are satisfied,
(d) both capital and labor market-clearing conditions Eqs. 17 and 19 hold,
(e) and the good market-clearing condition is satisfied,

$$F(K_t, A_t L_t) + K_t(1-\delta) = K_{t+1} + \sum_{x=0}^{\Omega-1}\sum_{j\in\mathbb{J}} g_{t,x}^j N_{t+1,x+1} + \sum_{x=T_w}^{\Omega-1} \lambda_{t,x} c_{t,x} N_{t+1,x+1}. \qquad (24)$$

Note this last condition is equivalent to Eq. 2. Moreover, the total consumption in the economy, including children's consumption, is taken into account in the last term of the right-hand side of the equation.

Finally, it is worth remembering that total private transfers given equal total private transfers received.

4 The estimation of the Spanish wealth

Figure 1 illustrates with blue circles the LCD of Spain in 2000. This implies that 21.5 million people (53.5% of the Spanish population) consumed more than they produced in 2000. In the year 2000, the Spanish life-cycle deficit is negative for the working ages 26–58. Nevertheless, the degree of economic dependency varies with age. As previously mentioned, children are, economically speaking, the most dependent since they neither work nor accumulate assets to finance their consumption. Their consumption needs are entirely supported by

[16] Although the increase in public debt with respect to GDP in 2009 is expected to have an important impact in the short and medium run in interest rates, it is likely that a misleading progressive income tax will have a stronger effect in the long run on the accumulation of capital.

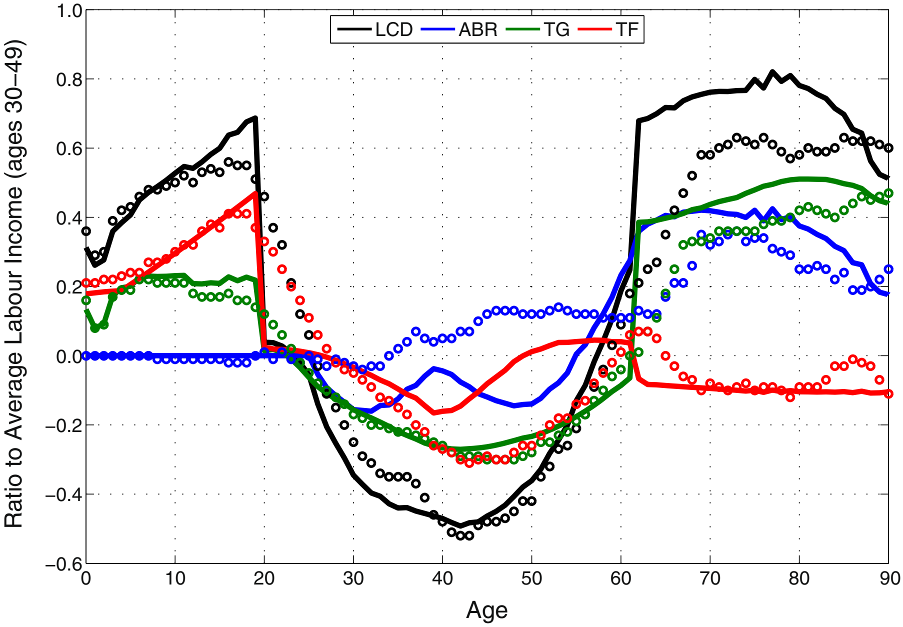

Fig. 1 Actual (*circled line*) and simulated (*line*) per capita life cycle deficits: Spain, year 2000

public transfers (38.2%) and familial transfers (61.8%). By contrast, the cost of supporting people from age 59 and over is lessened because they accumulate wealth before retirement. Indeed, in Spain retirees at age 65 finance 54% of their LCD with assets.

The Spanish life-cycle deficit by age has been calibrated by targeting the NTA age profiles, the main Spanish macroeconomic statistics, and the Spanish government budget in the year 2000. Figure 1 shows the differences between our simulated NTA profiles (solid-colored lines) and the actual NTA data (colored circles) in 2000. The discrepancies between the simulated and actual NTA profiles can be attributed to features of the real world that the model abstracts from. The most relevant would be as follows: the closed economy assumption that implies differential adjustment in wages and interest rates, the assumption of a given age of entry in and exit from the labor market, the shape of utility function, and the fact that the NTA profiles do not include bequests (see footnote 9). As a result, in our simulations, the sharp increases and decreases at ages 21 and 63 are due to the assumption that individuals leave their parental home when they are 21 years old and retire at age 63. In Spain, the median age at leaving the parental home was 25.7 years for men and 22.9 years for women in the early 1990s (Aassve et al. 2002). Provided that in our model both the individual decision-making and demographic characteristics are consistent, parental emancipation around age 25 would lead to an excess in fertility between ages 25–49 and, as a consequence, a burden 15 years later that would unrealistically reduce savings for these age groups.

On the other hand, although a mandatory age of retirement is an unrealistic assumption, the aim of the paper is not to estimate how the optimal age of retirement evolves with changes in demography and economic incentives but to understand the process of accumulation of wealth.[17] Thus, in order to keep the model as simple as possible, we have opted for assuming a constant age of retirement close to the official mean age of retirement in Spain in year 2000.

Another discrepancy between the NTA profiles and our simulation results is that our LCD profile is slightly higher for ages 63 and over. There are several reasons that may explain the difference. Among others, our endogenously determined (real) interest rate is high relative to actual data (around 1% higher), and thus the slope of our consumption profile for the elderly is steeper than what the NTA LCD profile shows. However, the sensitivity analysis test shows that the Euler equation is robust to changes in both the risk aversion coefficient and the subjective discount factor, and thereby, a different value in either variable cannot explain the discrepancy. Unlike Gan et al. (2005), an alternative explanation is that elderly people do not forecast accurately the remaining number of years lived. Indeed, we are assuming that all the remaining years lived are healthy years, which could tilt the consumption at old ages up.

There are some features of the Spanish NTA that need to be highlighted. First, ABR is close to zero up to age 40, and it only counts for 15% of the average gross labor income from ages 30 to 49 (18,410 euros) until retirement. Based on the life cycle theory of saving, this profile suggests that there are important inter vivos transfers that most likely flow from parents to adult children due to cohabitation and housing subsidies. Second, the positive ABR from age 40 until retirement occurs because, in 2000, the cost of childrearing peaks from age 35 to age 50 at the expense of savings. Moreover, the presence of sizable public transfers for retirement might also reinforce this effect. Third, the familial transfer profile is positive for children and negative for adults. Hence, parents are (net) transfer givers to their offspring through their lifetimes. A cross-country comparison shows that this is a generalized behavior, except in countries such as Taiwan, South Korea, and Thailand, where adults ages 65 and over are (net) recipients of familial transfers (Lee and Mason 2010). In contrast, individuals receive public transfers when they are younger than age 20 or older than age 62.

In 2000, the favorable demographic situation makes it easy to support the welfare state.[18] Unfortunately, assuming the current public benefit formulae remain in force, the simulation results show that the working age population will have to spend a higher proportion of their gross salary to support the

[17]This is a very interesting question that has been previously modeled for the Spanish case by Jimenez-Martin and Sanchez-Martin (2007) to analyze the effect that minimum pension benefits has on the optimal age of retirement or by Díaz-Giménez and Díaz-Saavedra (2009) to study how a change in the mandatory age of retirement affects the sustainability of the Spanish pension system.

[18]In fact, the total dependency ratio in Spain from the year 2000 to 2010 was the lowest of the last century.

welfare state system in 2050. Specifically, the payroll tax (our adjustment variable) increases from 16% in 2000 to 40% in 2050 (or equivalently social benefits in cash represent 8.9% of GDP in 2000 and about 22.7% of GDP in 2050) and the value added tax goes from 8.6% in 2000 to 11.4% in 2050. The effect of this adjustment can be appreciated in Fig. 2. In 2050, TG becomes much more negative at working ages, and it approaches the LCD.

An increase in the cost of the welfare state in 2050 is not the only change in the LCD. The change in TF is just as dramatic as the change in public transfers, as Fig. 2 illustrates. Surprisingly, in 2050, TF is positive for the working age population. A closer look at the evolution of familial transfers over time helps to explain this feature. Figure 3 shows the familial transfer wealth, i.e., the present value of the (net) lifetime familial transfers (as a share of lifetime labor income) expected to receive by a cohort in the year they enter the labor market. Interestingly, the present value of interfamilial transfers goes from zero, for the cohort entering the labor market in 2000, to a large positive value for the cohort entering the labor market while the baby boomers are retiring. To understand this picture, we need to look at the demographic characteristics of the Spanish population. People born during the baby bust receive more transfers from their older family members than they will actually give to their adult offspring; this is especially true among people who were born in the early 1990s, when the total fertility rate bottomed out. The opposite is also true

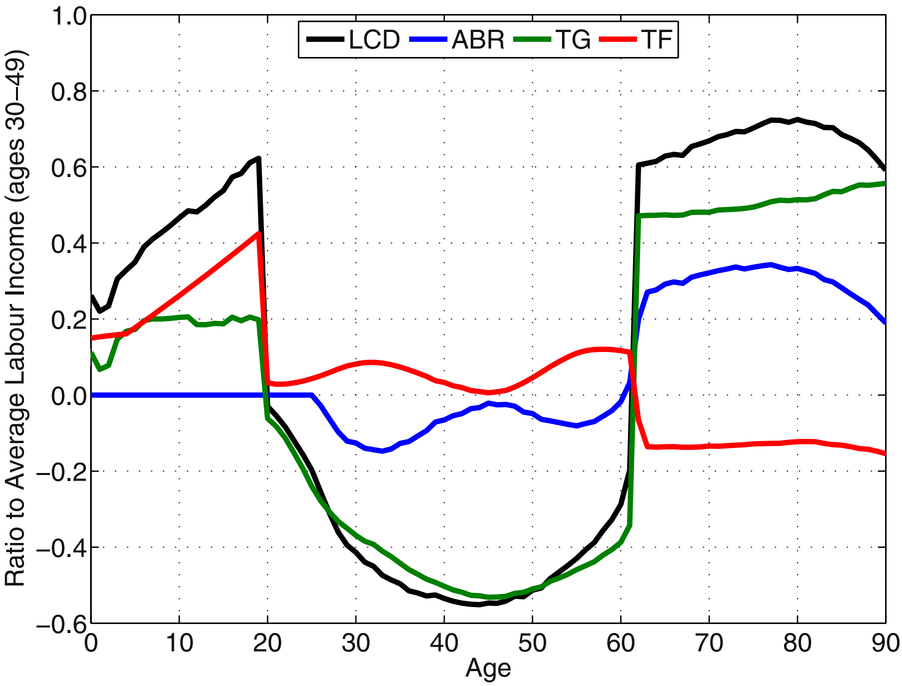

Fig. 2 Simulated per capita life cycle deficit: Spain, year 2050

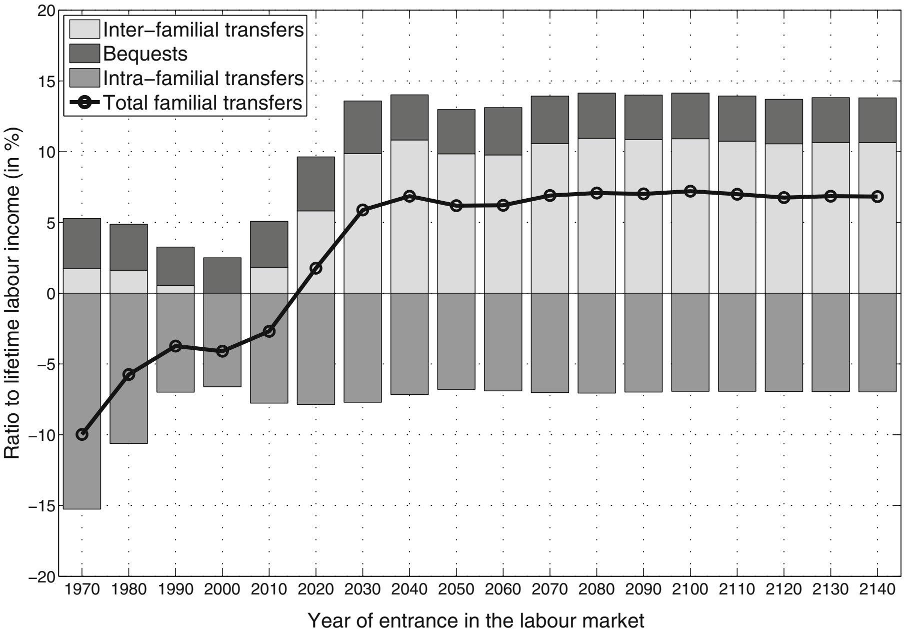

Fig. 3 Present value of familial transfers when entering the labor market: Spain, 1970–2140

for the baby boomers. This economic effect is similar to the one described by Easterlin (1980), in comparison of the economic fortunes of small cohorts relative to those of big cohorts. We can see how interfamilial transfer wealth raises starting from the small cohort born in the early 1990s. On the other hand, intrafamilial transfers lower but also substantially change over time due to the reduction in fertility and hence in childrearing costs.

The result of combining aggregate public and familial transfer wealth gives a positive transfer wealth for the twenty-first century, illustrated by the circled solid line in Fig. 4. Contrary to Fig. 3, this figure shows transfer wealth and its components for population alive in each year. Since $T > 0$ from 1990, according to Fig. 4, individuals will claim to have more wealth than the existing stock of capital. We know that, up to a certain threshold, if the population is declining, individuals' total wealth could exceed the existing stock of capital without depleting it. However, based on Eurostat projections of annual migrant flows, we have to rule out this possibility because our projected Spanish population continues to increase (in effective units) up to 2020.[19] As a consequence, the second demographic dividend will not be permanent (Mason and Lee 2006) since transfers to the elderly are quite generous and private transfer wealth becomes positive. In short, the additional accumulation of assets because of an extended retirement period (longer life

[19]See Fig. A-7 in the Appendix of Supplementary material.

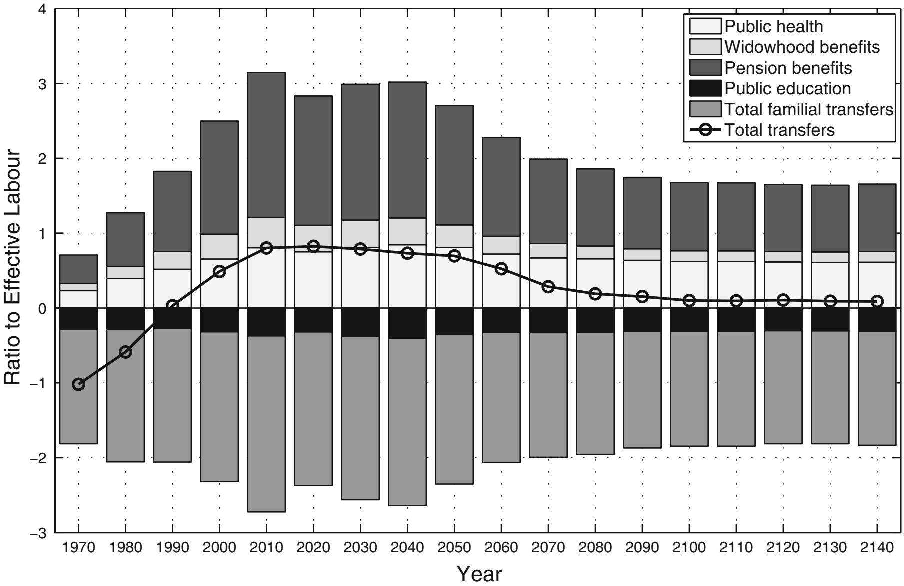

Fig. 4 Simulated aggregate transfer wealth: Spain, 1970–2140

expectancy after retirement) will lead to an increase in the capital-to-output ratio, but this increase, or second demographic dividend, will be temporary. Our simulations suggest that the capital-to-output ratio will reach the value of 3.75 in the 2040s and will progressively decline to a steady level of about 3.27.

Figure 5 shows the evolution of the capital market, including total wealth.[20] The equilibrium interest rate is represented in the vertical axis, while the capital in units of effective labor are on the horizontal axis. The black solid line corresponds to the supply of capital in equilibrium, or aggregate asset holdings, from 1980 to 2140 (when the final steady state is reached). The blue solid line is the associated total wealth over time or the wealth that individuals have to satisfy their remaining lifetime consumption. Taking this into account, for any given year, if total wealth exceeds the supply of capital, the population expect to consume more during their remaining lifetime than the existing stock of capital allows them to. This is because they expect to be net receivers of transfers throughout their lifespan (Lee 1994).

Even though total wealth exceeds the stock of capital, the entry of the baby boomers, who have more capital accumulated than previous cohorts, into retirement will boost the capital stock per worker up to 2040. The after-tax real interest rate will be close to 4% in 2040, and the productivity of labor

[20] Assuming a Cobb–Douglas production function with a capital share of $\alpha = .36$, capital-to-output ratio values of 3.75 and 3.27 correspond to capital per effective units of labor values of 7.9 and 6.35, respectively, which are contained in the solid black line in Fig. 5.

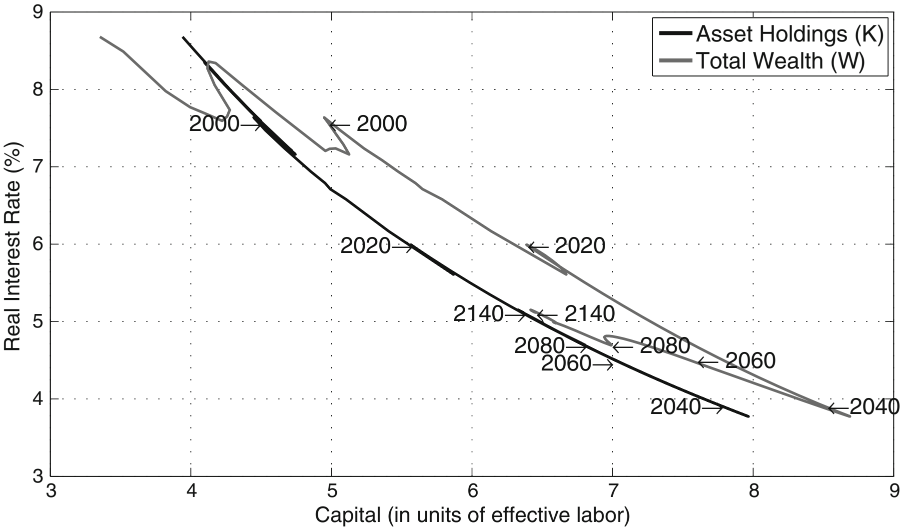

Fig. 5 Equilibrium interest rate and wealth (total wealth and asset holdings): Spain, 1980–2140

will increase at a rate of 1.59% per year from 2010 to 2040.[21] Simultaneously, payroll taxes will double during the same period, offsetting the gain in labor productivity. Hence, by maintaining the current social security system, net wages start decreasing in 2030 and capital in 2040, while consumption keeps growing until 2048. It is noteworthy the effect that the current economic crisis has on asset holdings and total wealth from year 2010 to 2020.[22] According to Fig. 5, the stock of capital decreases, whereas total wealth remains unchanged. This is because the generation who were born in the 1990s, with positive total transfers wealth, does not accumulate savings at the same rate as the growth rate of employment. Hence, the simulation suggests that the Spanish economy will need more than a decade to have the same stock per effective labor than before the economic crisis.

How will the decrease in net wages affect the stock of capital? On the one hand, the stock of effective capital will fall because of the decrease in net

[21] Assuming a Cobb–Douglas production function, the increase in labor productivity was calculated according to the formula:

$$\log \frac{\omega_{t+T}}{\omega_t} = \log \frac{A_{t+T}}{A_t} + \alpha \log \frac{k_{t+T}}{k_t}.$$

Assuming that at time $t + T$, any variable X_{t+T} can be expressed according to an initial value X_t times a constant growth rate g_X during T periods, then we find that the growth rate of salaries g_w is equal to $g_A + \alpha g_k \approx 1.26\% + 0.36 \cdot 0.93\% = 1.59\%$, where the set $\{g_A, g_k\}$ correspond to the growth rate of the labor-augmenting technological progress and the growth rate of effective units of capital, respectively.

[22] We have assumed that the observed employment rates by age in 2010 linearly improve to the values projected by the European Policy Committee in 2009.

wages, and the accompanying decline in saving rates. On the other, the stock of effective capital will rise because of the decrease in the population, assuming the rest of the variables remain the same (Lau 2009; d'Albis 2007). According to our simulations, the decrease in the net wage has a greater impact than the negative population growth rate and the longer life expectancy. However, the net wage decline does not fully explain the stock of capital in the new steady state. Most likely, the baby boom–baby bust (demographic effect), coupled with a generous welfare system (economic effect), explain the path to the new steady state. The aging of the population opens a second window of opportunity by increasing the capital-to-labor ratio when baby boomers exit to retirement (Mason and Lee 2006). This demographic effect counts for the increase of the effective capital from 2010 to 2040. The baby bust generation will save less than the baby boomers. First, the baby bust generation expect to be net receivers of interfamilial transfers, which increases consumption (see Fig. 3). Second, the increasing number of retirees raises the cost of financing the welfare state, which reduces the disposable income of the baby bust generation. The combination of both effects will progressively reduce the capital-to-labor ratio until the new equilibrium is reached.

In the new steady state, real and life-cycle wealth are higher than those in 2000 (see Fig. 5). Assuming technology will not change, the increase in the capital-to-labor ratio will lead to a 2% decrease in the real interest rate and a subsequent increase in the wage rate. Consequently, aggregate consumption will be greater in the final steady state than in 2000. The downside of Fig. 5 is the progressive movement to the left of the life-cycle wealth from 2050 up to the final steady state.

5 Conclusion

In this paper, we start for a new data set to investigate how the shape and direction of intergenerational transfers might affect capital accumulation in face of population aging. To that purpose, we have implemented a general equilibrium OLG model that includes realistic public and familial transfers. The size and direction of the observed Spanish intergenerational transfers draw upon the NTA database, a new international database that makes available estimates of market and nonmarket interage flows that are consistent with NIPA.

Provided the set of transfers by age in 2000 is maintained in the future, the simulation results show that net wages start decreasing in 2030. Nevertheless, asset holdings and consumption, both in per capita terms, experience a temporary and considerable increase until 2040 and 2048, respectively. We show how the rapid increase in both variables is due to the pronounced baby boom and baby bust in Spain. First, capital per unit of effective labor increases because the population at working ages decreases (even with migration) and because workers have access to a greater stock of productive capital. This is known as the second demographic dividend (Mason and Lee 2006), which turns out temporary in the simulation. Second, consumption per capita rises because of the increase in transfer wealth. Thus, on the one hand, baby boomers benefit from the current social security system, receiving substantial benefits relative to their contributions. On the other hand, the baby bust generation are depleting their capital because they have received a large quantity of inter vivos transfers from their parents (baby boomers), relative to the amounts they will leave to their children.

In summary, the effects of the Spanish baby boom and baby bust, coupled with the generous pension benefits, will lead to a progressive decline in the stock of capital in units of effective labor. Thus, salaries will decrease, yielding lower aggregate consumption, higher interest rates, and consequently a temporary second demographic dividend.

Further research is needed in order to explore the extent to which the results depend on the underlying model assumptions. Undoubtedly, the evolution of capital depends very much on the assumptions taken on saving motives and, more generally, on the extent to which altruistic behavior affects savings and fertility as the economy develops. The NTA data set might give interesting insights as long as additional waves allow for longitudinal analysis and a thorough comparative cross-country analysis can be derived. This might help to disentangle all the information embodied on the NTA cross-sectional profiles, which range from behavioral assumptions to economic and demographic conditions. The approach taken in this paper could be seen as a starting point for this line of research.

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