The effects of education and aging in an OLG model: long-run growth behavior in France, Germany and Italy

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Abstract

The purpose of the paper is to provide a long-run analysis up to 2050, of the interplay between financial integration, diverging labor productivity and aging processes in the larger European countries. To achieve this we use the Prometeia overlapping generation (OLG) model for Italy, Germany, and France modeled as open economies in capital markets.

Our projections provide a core-periphery structure where Germany, the most abundant human capital country, grows at the highest but decreasing rate due to pronounced aging, and finances the capital accumulation processes in France and Italy. We find that financial trends are reversed in the late 2010s when Italy starts to over-save as the gap in human capital endowment, and then productivity becomes larger compared to the other countries. This leads Italy to reduce its physical capital accumulation and innovation processes.

We provide fiscal experiments to correct the long-run divergent behavior of countries, in order to get a more homogeneous growth

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rate path among countries. We also measure the impact of net-wealth taxation in Italy and evaluate internal and spillover effects.

1 Introduction

European monetary and economic union is the most relevant institutional design for fostering the convergence of economic growth and financial stability in the EU member countries. It is a necessary but not sufficient condition for achieving these goals but to avoid divergent growth among European countries, and to enable long-run economic integration will require numerous other structural and institutional reforms. Since the early 2000s, scholars were worried about the optimality of an imperfectly designed monetary union. They argued that, if an idiosyncratic shock were to hit a member of the European monetary union in the absence of political integration, federal fiscal redistribution, and internal labor migration fluxes this would result in a difficult adjustment and loss of flexibility. Some years later, all the European economies were affected by a systemic not an idiosyncratic shock leading to a concern about the heterogeneous consequences for and different responses of a homogenous group of countries. The Great Recession has revealed structural dissimilarities in EU countries leading scholars to focus on the need for structural reforms. The interaction between the Great Recession and structural reform is used to fuel arguments amongst economist in relation to secular stagnation. Eichengreen (2015) argues that potential US, and therefore EU output, has been permanently reduced by the Great Recession, high unemployment levels, and the consequent impoverishment of their human capital.

Potential explanations for secular stagnation include: the "global saving glut" - since the late 1990s due to high savings rates in emerging countries (Bernanke (2005)), and "underconsumption" (or "oversaving") caused by inequality in the distribution of wealth and income (Piketty (2014)).

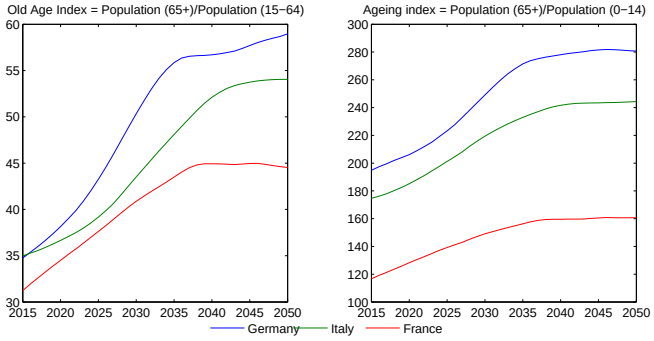
The reduction in the rate of investment triggered by declining population growth is one of the cornerstones of Hansen (1938)'s hypothesis of secular stagnation. It is related to the downward trend in real interest rates as a result of excess desired saving over desired investment which causes a sustained lack of aggregate demand and low economic growth. However, Eichengreen (2015) points out that Hansen (1938) did not imply that slower population growth and greater longevity would be accompanied by lower savings rates.

The declining birth rates and increased life expectancy in recent decades

are the main reasons for the growing relative number of retirees (dependency ratio) in most European countries.

Figure 1 illustrates the extent of the demographic changes underway in Germany, Italy, and France which are the European countries most affected by aging. The levels between countries differ but the trend is increasing in all three countries with a shift in the young-old balance. The right-hand chart in the figure shows the old-age dependency ratio computed as the ratio of the population over 65 and population of working age between 15 and 64 years. It provides a measures of potential social support needs (in terms of pensions) that will have to be borne by the working age population in future decades and raises the problem of financing increasing public retirement income provision. The left-hand chart indicates the ratio of those persons aged over 65 per each group of 100 children aged under 15. This is projected to rise by more than 30 percent in each of the three countries in 2015 to 2050.

Figure 1: Aging index disparities



Source: Eurostat

Figure 2 shows the total population in each age range in 2015 and 2060 for all three countries, and indicates a faster aging process in Germany and Italy compared to France.

To compensate for the effects of an aging-induced reduction in labor supply on production, labor productivity needs to increase, requiring an offsetting policy to increase human capital formation and the size of the labor factor. Without the implementation of proactive policies the shortage of labor will lower saving rates which could trigger a slowdown in the demand for investment goods, capital accumulation, and hence economic activity. Therefore, aging will lead to changes in the capital-to-labor ratio, resulting in lower rates of return and lower investment.

Eichengreen and Fifer (2002) find that an increase in the dependency ratio has roughly the same negative impact on saving and investment rates, and a minimal impact on interest rates and current account balance of payments.

Figure 2: Total population: 2015 vs. 2060

Source: Eurostat

Goodhart and Erfuth (2014) investigate the role played by current population growth in determining the recent decline in real interest rates. Given that both advanced and emerging countries are experiencing lower population growth - which implies lower saving rates - Goodhart and Erfuth argue that as long as populations continue to decrease, real interest rates can be expected to increase. The empirical analysis performed by Favero and Galasso (2015) on a panel of countries concludes similarly that interest rates will increase in the medium term.

However, the decline in the supply of labor induced by aging may re-

duce the rate of return and the incentive to save while an increase in human capital might work to adjust this trend thereby offsetting the shrinking effect of aging on the labor force. The effect of increasing human capital accumulation is analyzed by Fougère and Mérette (1999), Sadahiro and Shimasawa (2002), Buyse et al. (2012), Ludwig et al. (2012), and Heijdra and Reijnders (2012). Human capital raises the quality of labor, and lowers the capital per unit of effective labor. Thus, the impact of population aging on factor prices can be counterbalanced.

As Vogel et al. (2014) point out, labor market policies aiming at making adjustments to the education margin can boost endogenous economic growth by increasing labor productivity thereby providing an incentive for public investment in education. The same effect holds for adjustments to the extensive margin through reforms to the pension system, given that a shrinking working population accompanied by the current pension commitments in advanced countries could cause increased pressure on the pension budget.

We use a multi-country model with overlapping generations and endogenous growth to assess the mechanisms through which population aging affects economic growth. We build a human capital index that is included in the formulation of endogenous TFP in order to account for the role of labor productivity in determining GDP growth projections from 2015 to 2050. We focus on those European countries where aging is proceeding faster (Italy and Germany) and compare them with France where population aging is slower. We observe similar trends in human capital grown in France and Germany and a lag in Italy. We include these trends in Prometeia's OLG model for Italy, Germany, and France, modeled as open economies in capital markets as in Börsch-Supan et al. (2006). Our projections provide a core-periphery structure where Germany, the country with the most abundant human capital among the three being studied, grows at the highest rate but at a decreasing rate due to pronounced aging, and finances the capital accumulation processes in France and Italy. We find that in the late 2010s these financial trends are reversed and Italy starts to over-save as the gap in human capital endowment and then in productivity becomes larger compared to the other two countries. This leads to Italy reducing its physical capital accumulation and innovation processes. Our analysis is focused on a baseline scenario - with open economies and no policy intervention - and alternative scenarios with fiscal policy changes. In a closed economy scenario, different population demographics among the countries result in different saving and investment rates, and different rates of return on capital. In a context of an open economy (as opposed to a closed economy scenario) with perfect capital mobility, capital flows will determine

an equalized rate of return on capital among countries which changes the impact of aging on each country's saving behavior and output growth. In a context of an integrated economy (in terms of capital mobility), if there is excess demand for financial assets in one country (typically a country with a relative young population) this will be covered by the inflow of foreign capital (from those countries with a relatively old population). However, aging might result in exporting countries becoming capital importers. Therefore, if one country's savings decline because of aging, investment may not follow suit and excess capital imports/exports will need to be adjusted in order to avoid strong imbalances among countries.

The remainder of the paper is organized as follows. Section 2 presents a description of the model. Section 3 describes the parameters and targets on which the model is calibrated. Section 4 discusses the benchmark model and its implications. Section 5 describes the thought experiments and section 6 discusses the results. Finally, section 7 concludes the paper. Appendix A provides the projections related to the simulated experiments described in section 6.

2 The model

The model is a multi-country OLG model that includes endogenous growth, real wages, interest rates, benefit payments, and government spending on education. It is a general equilibrium system that includes long-term demographic and human capital projections for Italy, France, and Germany in order to evaluate the impact on long-run output growth. We focus on the countries' different saving behavior induced by population aging, and analyze the dynamics of international capital flows on the period considered - 2015 to 2050.

The model's core sectors are households and firms. Households set life-cycle saving decision in perfect foresight. They differ in terms of age and education level. As we approximate human capital quality as a measure of schooling duration (section 3), we consider three different education levels: primary and lower secondary (LS) (which implies that agents complete 8 years of study), upper secondary (HS) (completion of 13 years of study), and tertiary level (TS) (completion of 18 years of study). Therefore, in each year, the economy is populated by 303 overlapping generations of unisex agents that live for 101 years (multiplied by 3 education levels). In the baseline setup, government draws resources from the active labor force via labor income taxes while revenues from taxes on net wealth are used to finance investment.

2.1 Households

Each cohort is represented by one household which maximizes the discounted lifetime utility by choosing consumption and leisure over the life cycle from entry to the labor market (at the earliest aged 15) to their death (aged 101). In each country j, with j=*Italy, France, Germany*, the utility of a cohort at age s with the education level i is given by

$$U_s^i = \sum_{t=s}^{s+T} \left(\frac{\left\{ u\left[c_s^i(t), (e_s^i(t) - l_s^i(t)) \right] \right\}^{1-1/\xi}}{1-\frac{1}{\xi}} \right) \left(\frac{1}{(1+\rho)^{t-s}} \right) \qquad (1)$$

where T is the longevity (101 years for all agents), ρ denotes the rate of time preference which is cohort invariant, and ξ determines the degree of intertemporal substitutability of consumption and leisure, which is also cohort invariant. $c_s^i(t)$ denotes the consumption in year t of the cohort that enters the economic system in year s, with education level i, with i = *LS, HS, and TS*. Labor supply, $l_s^i(t)$, is measured in efficiency units relative to the time endowment $e_s^i(t)$. Hence, leisure $e_s^i(t) - l_s^i(t)$ is subject to time endowment constraint, $0 \leq l_s^i(t) \leq e_s^i(t)$. We assume that $e_s^i(t)$, like the other variables in the model, grows at the human capital technology rate. The age each coohort enters in the market is tl and it depends on the education level. The lifetime utility in equation (1) for the cohort born in years $s - tl$ that enters the labor market in year tl can be written as follows

$$\begin{aligned} U_s^i = & \sum_{t=s}^{s+\Delta_i-1} \left(\frac{\left\{ u\left[\tilde{c}_{s-tl}^i(t) \right] \right\}^{1-1/\xi}}{1-\frac{1}{\xi}} \right) \left(\frac{1}{(1+\rho)^{t-s}} \right) + \\ & + \sum_{t=s+\Delta_i}^{s+Tr_s(t)-1} \left(\frac{\left\{ u\left[c_{s-tl}^i(t), (e_{s-tl}^i(t) - l_{s-tl}^i(t)) \right] \right\}^{1-1/\xi}}{1-\frac{1}{\xi}} \right) \left(\frac{1}{(1+\rho)^{t-s}} \right) + \\ & + \sum_{t=s+Tr_s(t)}^{s+T} \left(\frac{\left\{ u\left[c_{s-tl}^i(t) \right] \right\}^{1-1/\xi}}{1-\frac{1}{\xi}} \right) \left(\frac{1}{(1+\rho)^{t-s}} \right) \end{aligned}$$

where Δ_i is the differential of education years with respect to the lower education level, $Tr_s(t)$ is the years of contribution needed to obtain the pension, $\tilde{c}_{s-tl}^i(t)$ is the consumption of agents before entering the labor market (i.e., during the period of education), $c_{s-tl}^i(t)$ denotes consumption during the working period (before retirement i.e. until period $s + Tr_s(t) - 1$) and in the retirement period (i.e. from period $s + Tr_s(t)$ onwards), and $l_{s-tl}^i(t)$ is the individual labor supply.

The within period utility - of the constant elasticity substitution type - for a particular year s for an individual that starts working at age tl is

given by

$$u(c^i_{s-tl}(t), e^i_s(t) - l^i_{s-tl}(t)) = \left[c^i_{s-tl}(t)^{(1-\frac{1}{\epsilon})} + \alpha \left(e^i_{s-tl}(t) - l^i_{s-tl}(t)\right)^{(1-\frac{1}{\epsilon})}\right]^{\frac{1}{1-\frac{1}{\epsilon}}} \tag{2}$$

where ϵ denotes the substitutability of consumption and leisure and α the intensity of preference for leisure relative to consumption.

The dynamic budget constraint is:

$$a^i_{s-tl}(t+1) = \begin{cases} \frac{1}{q^i_{s-tl}(t)} \left(1 + r(t) - \tau_k\right) a_{s-tl}(t) + y^i_{s-tl}(t) - c^i_{s-tl}(t) & \text{if } s \leq s + Tr_s(t) - 1 \\ \frac{1}{q^i_{s-tl}(t)} \left(1 + r(t) - \tau_k\right) a^i_{s-tl}(t) + pen^i_{s-tl}(t) - c^i_{s-tl}(t) & \text{if } s \geq s + Tr_s(t) \end{cases}$$

where $a^i_{s-tl}(t)$ denotes the wealth in year t of the cohort born in the period $s - tl$, $r(t)$ $y_{s-tl}(t)$ $pen_{s-tl}(t)$ are respectively the interest rate, the post tax labor income and the pension for the cohort born in the period $s - tl$ in year t. The term $\frac{1}{q_{s-tl}(t)} = \frac{f_{s-tl}(t+1)}{f_{s-tl}(t)}$ denotes the annuity associated with mortality, where $f_{s-tl}(t+1)$ is the probability of surviving in $t + 1$. τ_k is the exogenous tax rate imposed by government on wealth to finance public investment. The lifetime budget constraint for the generation born in the period $s - tl$ is:

$$\sum_{t=s}^{s+T} \left[\frac{c^i_{s-tl}(t)}{\Pi_{t=s}^{s+T}(1 + r(t-s) - \tau_k)}\right] = \sum_{t=s}^{s+T} \left[\frac{y^i_{s-tl}(t) + pen_{s-tl}(t)}{\Pi_{t=s}^{s+T}(1 + r(t-s) - \tau_k)}\right]. \tag{3}$$

Labor income $y^i_{s-tl}(t)$ will be equal to

$$y^i_{s-tl}(t) = \left(\frac{w}{p}(t) l^i_{s-tl}(t) h^i_{s-tl}(t) + \mu_{s-tl}(t)\right)(1 - \tau_l(t)), \tag{4}$$

where $\frac{w}{p}(t)$ is the real wage, $l^{t-s(t)h^{t-s}(t)}$ represents the effective unit of labor in year t for an agent that was born in the year $s - tl$, with $h^i_{s-tl}(t)$ denoting labor productivity that depends on age, birth year, and education level. $\mu_{s-tl}(t)$ is the shadow value of leisure, and $\tau_l(t)$ denotes the exogenous contribution tax rate.

The optimal labor/leisure choice gives the following first order condition (FOC):

$$e^i_{s-tl}(t) - l^i_{s-tl}(t) = \left(\frac{u_{s-tl}(t)}{\alpha}\right)^{-\epsilon} c^i_{s-tl}(t), \tag{5}$$

where $u^i_{s-tl}(t) = \left(\frac{w}{p}(t) h^i_{s-tl}(t) + \mu_{s-tl}(t)\right)(1 - \tau(t))$ denotes the effective cost of leisure.

The Euler equation for the intertemporal consumption choice is:

$$\frac{c^i_{s-tl}(t+1)}{c^i_{s-tl}(t)} = \left[\frac{1+r(t+1)-\tau_k}{1+\rho}\right]^{\xi} \left[\frac{1+\alpha\epsilon(u^i_{s-tl}(t+1))^{1-\epsilon}}{1+\alpha\epsilon(u^i_{s-tl}(t))^{1-\epsilon}}\right]^{\frac{\epsilon-\xi}{1-\epsilon}}. \quad (6)$$

If $l = 0$, there is no labor supply and this means that:

$$\frac{c^i_{s-tl}(t+1)}{c^i_{s-tl}(t)} = \left[\frac{1+r(t+1)-\tau_k}{1+\rho}\right]^{\xi}. \quad (7)$$

2.2 Firms

In each country j, the production sector is characterized by a representative firm i which uses a Cobb-Douglas technology with increasing returns to scale that combines the capital stock, $K_i(t)$, with the effective labor input, $L_i(t)$:

$$\begin{aligned} Y_i(t) &= F\left(TFP_i(t), K_i(t), L_i(t)\right) \\ &= TFP_i(t) K_i(t)^{\beta} L_i(t)^{1-\beta} \end{aligned} \quad (8)$$

where β is the capital share, $L_i(t)$ denotes the hours worked in efficiency units given our human capital evaluation.

The firm's profits are defined as

$$\pi_i(t) = Y_i(t) - (r_i(t) + \delta - \tau_k)K_i(t) - (w/p)_i(t)L_i(t) \quad (9)$$

where δ denotes the depreciation rate, and τ_k is the exogenous tax rate on wealth. The first order conditions from profit maximization give the following wage and interest rates:

$$\begin{aligned} r_i(t) &= \beta\frac{Y_i(t)}{K_i(t)} - \delta(t) + \tau_k(t) \\ (w/p)_i(t) &= (1-\beta)\frac{Y_i(t)}{L_i(t)}. \end{aligned} \quad (10)$$

$TFP_i(t)$ in equation (8) denotes the endogenous total factor productivity that is directly affected by both the capital/labor ratio and the human

capital per worker, as follows

$$TFP_i(t) = \left(\frac{K_i(t)}{N_i(t)}\right)^g H(t)^z, \tag{11}$$

where g and z denote the contribution of the production factors to total factor productivity (TFP). In particular, g measures the rate of creation of capital per worker, and z is the rate of creation of new ideas or technologies (see section 3).

This implies that the innovation process is proportional to the number of ideas and amount of equipment per employee so that higher human capital makes the allocation of capital more productive. These externalities affect both factors of production - capital and labor - and determine the increasing returns to scale of the production function.

2.3 Government

In each country, the public sector consists of only two areas, namely the social security and education departments. The government raises funds through public debt and labor income taxes paid by workers at the exogenous taxation rate $\tau(t)$, and uses them to finance education and current pension and social transfers to retired people. Equation 12 government issues new debt in order to finance benefit payments $pen(t)$ given tax reveneus, so that:

$$\Delta B(t) = r(t)B(t) - \tau\frac{w}{p}(t)L(t) - \tau_k A(t) + sg(t) + transf(t) + pen(t), \tag{12}$$

where $transf(t)$ denotes government transfers to firms equal to the revenues from wealth taxation $\tau_k A(t)$; in particular, $\tau_k A(t) = I_g(t)$, such that $I_g(t) = K_g(t+1) - K_g(t)(1-\delta)$ represents public productive investment, with δ denoting the depreciation rate. $r(t)B(t)$ denotes the interest repayment on public debt and $\Delta B(t) = B(t) - B(t-1)$. $sg(t)$ denote public spending on education. The schools department distributes funds among those students that do not receive a work income. Students are rule-of-thumb consumers: they consume their entire current income (the value of their scholarship). The total amount of public expenditure on education $sg(t)$ will be equal to the weighted sum of agents that in t are studying to achieve the schooling level i, with *i=primary and lower secondary (LS), upper secondary (HS) and tertiary level (TS)*:

$$sg(t) = cs(t)\left[\sum_{s=1}^{15} c_{t-s}^{LS}(t)\frac{q_{t-s}^{LS}(t)}{q_{t-s}^{LS}(t)+q_{t-s}^{HS}(t)+q_{t-s}^{TS}(t)}+\right.$$
$$+\sum_{s=15}^{19} c_{t-s}^{HS}(t)\frac{q_{t-s}^{HS}(t)}{q_{t-s}^{LS}(t)+q_{t-s}^{HS}(t)+q_{t-s}^{TS}(t)}+$$
$$\left.+\sum_{s=20}^{24} c_{t-s}^{TS}(t)\frac{q_{t-s}^{TS}(t)}{q_{t-s}^{LS}(t)+q_{t-s}^{HS}(t)+q_{t-s}^{TS}(t)}\right],$$

where $cs(t)$ denotes the per capita scholarship, and $c_{t-s}^{i}(t)$ is the consumption of agents born in year $t-s$ with education level i.

2.4 Aggregation

In each country j, with $j = Italy, France, Germany$, the total labor supply $L_j(t)$ which accounts for the choice of all representative households in each generation is equal to

$$L_j(t) = \sum_{s=s_i}^{s_i+Tr_{s,j}(t)} l_{t-s,j}(t)h_{t-s,j}f_{t-s,j}(t), \tag{13}$$

and the aggregate amount of labor input is:

$$N_j(t) = \sum_{s=s_i}^{s_i+Tr_{s,j}(t)} l_{t-s,j}(t)f_{t-s,j}(t), \tag{14}$$

where $f_{t-s,j}(t)$ is the level of population of age s in year t; $Tr_{s,j}(t)$ denotes the contribution years required in year t to obtain the pension.

Aggregate wealth is given by

$$A_j(t) = \sum_{s=0}^{T} a_{t-s,j}(t)f_{t-s,j}(t), \tag{15}$$

where $T = 101$, and $a_{t-s,j}$ denotes the individual wealth accumulated in year t by each representative agent aged s.

The capital stock $K_j(t)$ in each country changes over the simulation period according to

$$K_j(t) = A_j(t) - F_j(t) - B_j(t) \tag{16}$$

where $F_j(t)$ denotes the amount of foreign assets, and $B_j(t) = \lambda_j Y_j(t)$ is the public debt. In the closed economy framework, the rate of return on capital in each country j is equal to the marginal productivity of capital $r_j(t) = mpk_j(t)$. Moreover, any country's foreign assets are equal to zero $F_j(t) = 0$, and the capital stock is simply equal to aggregate wealth $K_j(t) = A_j(t)$. When the economy is open and capital is internationally mobile, the rate of return on capital is equalized across countries $r_j(t) = r(t)$, such that the sum of all foreign assets across all countries equals zero, i.e. $\sum_{j=1}^{J} F_j(t) = 0$, with $J = 3$. Foreign assets in each country j are defined as the difference between total assets and the home capital stock $F_j(t) = A_j(t) - K_j(t) - B_j(t)$.

Countries most affected by aging (such as Italy and Germany) initially will be capital exporters, while countries (such as France) with younger populations will be capital importers because the higher labor supply will increase demand for investment goods given the need for more capital. Population aging will gradually reverse this path inducing a decrease in saving rates in faster aging countries, and capital flows will follow this trend.

Aggregate output - considering all the symmetric firms i in the model economy - is given by

$$Y_j(t) = TFP_j(t) K_j(t)^{\beta} L_j(t)^{1-\beta}. \tag{17}$$

2.5 Equilibrium

The dynamic general equilibrium of the economy is defined as a set of disaggregate variables for each country j, $\{C_{s,j}(t), N_{s,j}(t), A_{s,j}(t)\}_{t=t0}^{t1}$, aggregate variables $\{C_s(t), N_s(t), K_s(t)\}_{t=t0}^{t1}$, wage and interest rate $\{(w/p)_j(t), r_j(t)\}_{t=t0}^{t1}$ such that

1. Factor prices equal their marginal productivities

$$\begin{aligned} r_j(t) &= \beta \frac{Y_j(t)}{K_j(t)} - \delta + \tau_k, \\ (w/p)_j(t) &= (1-\beta) \frac{Y_j(t)}{L_j(t)}. \end{aligned} \tag{18}$$

2. Goods and labor markets clear

   In the open economy framework, market clearing on the international market requires that the rate on return on capital is equalized across countries, and the sum of all foreign assets in the system

equals zero:

$$\begin{aligned} r_j(t) &= r(t), \\ \sum_{j=1}^{J} F_j(t) &= 0 \end{aligned} \tag{19}$$

with $j = Italy, France, Germany$, and J is the number of countries in the model.

3. World output is

$$Y_t = \sum_{j=1}^{J} Y_j(t). \tag{20}$$

4. Foreign assets are defined as the difference between total assets and home assets, such that

$$F_j(t) = A_j(t) - B(t) - K_j(t) \tag{21}$$

and international capital flows are the difference between national savings and investment

$$\begin{aligned} CA_j(t) \equiv \Delta F_j(t) &= S_j(t) - I_j(t) = \\ &= Y_j(t) + r(t)F(t)_j - C_j(t) - I_j(t), \end{aligned} \tag{22}$$

where $Y_j(t) + r(t)F(t)_j$ denotes total national income (from domestic and foreign sources).

3 Calibration

The model calibration is based on the literature and on some targets built to match the data. We present the parameters for each country in table 1. For each country we set ϵ, the inter-temporal elasticity of substitution and ξ, the elasticity of substitution between consumption and labor, at 0.5 and .95 respectively. In order to take into account heterogeneous participation rates in the labor market we set the weights on leisure utility for Germany, Italy, and France (hereafter GIF) to 0.32, 0.27 and 0.33. In line with Vogel et al. (2014) we set ρ at 0.011 in order to obtain a capital-to-GDP ratio of 3 and a depreciation rate of physical capital δ to 0.035 to get a steady state investment-to-GDP ratio of 20 percent.

The human capital $H(t)$ is computed as a Törnqvist index:

$$H(t) = \frac{1}{2}\sum_{i=1}^{I} \Delta e_i(t) \left(\frac{\lambda_i(t)E_i(t)}{\sum_{i=1}^{I} \lambda_i(t)E_i(t)} + \frac{\lambda_i(t-1)E_i(t-1)}{\sum_{i=1}^{I} \lambda_i(t-1)E_i(t-1)} \right), \tag{23}$$

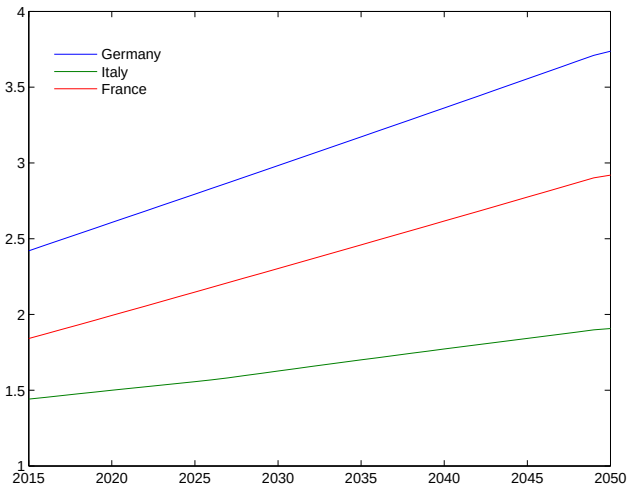
where I is the total number of education types (i.e. 3: LS, HS, and TS); $E_i(t)$ denotes people with education level i in year t; $\lambda_i(t)$ is a quality index for education level i (i.e., 8 years of study for level LS, 13 years for HS, and 18 for TS). $\Delta e_i(t)$ is the variation in the number of people with education i in year t compared with a basic year t_0, i.e. $\Delta e_i(t) = \ln\left(\frac{E_i(t)}{E_i(t_0)}\right)$[1].

We estimate the values for the endogenous total factor productivity (see section 2.2) by means of a vector error correction model in order to find the long run relationship between capital-to-worker ratio and human capital quality[2]. The values of capital and human spillover in TFP are respectively $g = 0.16$ and $z = 0.43$, that we also apply to Germany and France assuming that this process of innovation creation holds in those countries as well.

[1]For each country, Eurostat data on education from 1983 to 2013 are grouped by 29 age classes and 5 schooling levels (All; Less than primary, primary and lower secondary; Upper secondary and post-secondary non-tertiary; Tertiary education; No response). To compute the human capital index, we focus on 11 age classes (15-19,20-24,25-29,...,65-69) and three education levels (LS ; HS including post-secondary non-tertiary; TS). We use these data to estimate the education level for any single age s, with $s = 15, 16, \ldots, 69$. For an age not included in any class, i.e. for an age in intervals 0-14 and 70-101, we use information from the first and the last age class (15-19 and 65-69), respectively. Moreover, to match education data with population data in 1970-2080, we use extrapolation for missing years. In particular, we build education data from 1970 to 1983 by using information in period 1983-2013 (trend extrapolation), and education projections from 2014-2080 by using data for period 2000-2013. In addition, to take account of the saturation of entry to higher education, we allow the evolution of education to slacken in the last 30 years of projection: we assume that people older than 30 in period t continue to keep the education level of the previous age in period $t-1$.

[2]The endogenous TFP is defined as $TFP = (K/N)^g H^z$. We estimate the parameters g and z in the long-run relation $\log(TFP) = g\log(K/N) + z\log(H) + \epsilon_{tfp}$. To ensure the stability in the short-run, we estimate the following error correction function: $y_{tfp} = a_0 y_k + a_1 y_H + a_2 \epsilon_{tfp}$, where y_i denotes the growth rate, with $i = tfp, K/N, H$. The estimates give $g = 0.16(0.05)$ and $z = 0.43(0.08)$, $a_0 = 0.14(0.16)$, $a_1 = 0.39(0.27)$, $-0.21(0.11)$; standard deviation in parentheses.

Figure 3: Human capital index



Finally, we set the labor tax rates to calibrate the debt-to gdp ratio for each country. Schooling-to-GDP expenditure for GIF is set at 5.1 percent, 4.3 percent and 5.7 percent respectively.

Table 1: Model Parameters

		Ger	Ita	Fra
ξ	Intertemporal elasticity of substitution	.5	.5	.5
η	Labor-Consumption elasticity of substitution	.95	.95	.95
ρ	Pure time impatience rate	0.011	0.011	0.011
α	Weight of leisure utility	0.32	0.27	0.33
β	Share of capital in production	0.35	0.32	0.32
δ	Depreciation rate of capital	0.035	0.035	0.035
g	Capital spillover in TFP	0.16	0.16	0.16
z	Human capital spillover in TFP	0.43	0.43	0.43
τ	Labor tax rate	0.15	0.17	0.18
τ_k	Wealth tax and investment transfer rate	0	0.	0.
cs	Schooling expenditure on Gdp	0.051	0.043	0.057
$debt$	Debt to Gdp ratio	0.6	1.20	0.9

We simulate the model for an open economy with given structural parameters. In order to match historical GDP data we calculate an exogenous index of TFP that reduces the distance between the simulated and the

actual data. Combined with an increasing degree of economic openness this allows the simulation of endogenous capital movements (see next section).

4 Benchmark scenario

Based on the calibrations and population projections we can explore the natural evolution of the economy of GIF simulating it as explained in section 3 and describe the results from 1970 to 2050. Our analysis concentrates on a baseline scenario with open economies and no policy intervention, and alternative scenarios with fiscal policy changes. We assume an increasing degree of openness of the national economies starting from the closed economy steady state, and simulated transition to the full open economy scenario. When economies are closed, firms finance investment through internal saving. As economies participate progressively in an open capital market, aggregate capital and wealth stock may differ. In a closed economy scenario, different population demographics among countries will result in different saving and investment rates, and therefore different rates of return on capital. In an open economy context with perfect capital mobility, capital flows will determine an equalized rate of return on capital among countries that will change the impact of aging on each country's saving behavior and output growth. There are three basic factors that affect the interest rate in an integrated economic system with a unique capital market:

- The age structure of the population determines the average saving rate based on the life-cycle hypothesis: the younger the population, the higher the saving rate - in fact, the relationship between saving rate and age is non-linear. In the simplest case[3], the saving rate increases until the retirement age, then the relationship becomes negative and therefore the aggregate saving rate declines.
- The relative dimension of the economy matters: ceteris paribus, the total amount of financial capital supply available in the capital market will shrink proportional to the size of the credit economy. Therefore, aging not only reduces the average saving rate but also reduces its importance in absolute terms.
- The increasing return hypothesis: the richer the country in terms of physical and/or human capital, the higher will be economic growth and the higher and more positive the net foreign asset position.

[3]Such as in the absence of a voluntary bequest.

In a context of integrated economies (in terms of capital mobility), if there is excess demand for financial assets in one country (typically one with a relatively young population) this will be covered by the inflow of foreign capital (from countries with a relative older population). However, because of aging, exporter countries might become capital importers. Therefore, if one country's savings decline because of aging, investment may not follow suit and the interest rate will require adjustment in order to avoid strong imbalances among countries.

Figure 4 shows that demographic trends and the evolution of human capital (as depicted in Figure 3) affect countries differently. In a nutshell, we can identify the following tendencies:

- The transition phase will lead Germany to finance capital accumulation in France and Italy and cause them to become net creditors.
- Given a good mix of physical capital per worker, human capital endowment, and a younger population, France will grow at a higher rate achieving the highest capital stock per effective labor unit; this will invert the capital flow in 2020 leading to an improvement in France's net foreign asset position.
- In relation to net foreign assets, Italy will experience a similar evolution to France but this will not correspond to a higher growth process and will be associated with higher accumulation of net wealth stock.
- Given the overall evolution of the economy, interest rates will increase in the period 2015-2030, and decrease up to 2050 due to France's growth process and restored net saving supply.

The simulation starts from 1970 with the population of Germany, the biggest of the three countries, contracting and closing the gap with Italy and France. Due to the aging process, the German economy will shrink, reflected by an increasing dependency ratio. As a consequence, the labor supply will reduce at a faster pace with respect to France and Italy. At the same time, due to the calibration process, a higher exogenous TFP shock will cause Germany to grow at a higher rate and to accumulate a higher capital stock. Therefore, in the second half of the $20th$ century the capital-to-effective labor ratio is higher in Germany which determines that the rate of return on capital is the lower. Given increasing capital market openness in the period of transition to a full open economy, interest rates in France and Italy reduce until rates of return and capital-to-GDP ratios become equal. It is worth noting that the model predicts a reduction in interest rates for Italy and France but an increase in interest

rates for Germany until the $2000's$. Then in 2015-2030 the rate of return on capital increases as the whole economy is triggered by the effects of the aging process in Germany on aggregate saving which reduces in both mean and absolute terms. Therefore, the supply of financial capital will reduce leading to an interest rate increase.

Once the capital economy is fully open, the economies of Italy and France begin to grow at a higher rate. In particular, due to a combination of demographics and endogenous technological process innovation, France leapfrogs with respect to the leader economy. France's TFP accumulation process accelerates and leads wages, social transfers, and the capital-to-effective labor ratio to reach and overtake the level in Germany.

The full simulation shows a non-constant and heterogeneous level of net foreign assets burden for each country during the process of capital market opening. Germany quickly becomes a net creditor with respect to the other countries due mainly to the increasing returns in the economy that enable technological and financial leadership. A core-periphery structure emerges: the growth processes in Italy and France are financed in part by German households' wealth accumulation process. In the $2010's$ the process reverses and first Italy, and later France, start to divest themselves of foreign debt. The strength of Germany's role as a net creditor reduces, first Italy, then France, start to accumulate current account surpluses. The process in Italy progresses at a slower pace than in France where it is due to an accelerated capital and technological accumulation process, while in Italy the process reflects a financialization process. Due to low human capital growth and endowment, when capital markets become fully-open, the implicit comparative advantage - reflected by lower capital productivity - increases the incentives for agents in the Italian economy to reallocate their asset portfolios towards financial assets, and to reduce capital stock accumulation. This in turn, favors a slowdown in technological progress since the capital-to-labor ratio remains low, and an older population results in decreased aggregate saving.

Given this baseline scenario we can conclude that human capital and the aging process have a radical effect on the sustainability of an integrated economy (at least in the capital market). From this perspective, a higher saving rate in relation to a younger population, and a higher human capital endowment is likely to induce the formation of a core-periphery structure where the periphery grows at a lower rate. This diverging growth process could affect financial sustainability. Therefore, an economic policy aimed in particular at stabilizing the growth processes for the countries analyzed would be desirable. In the next section, we propose some policy interventions to increase European convergence.

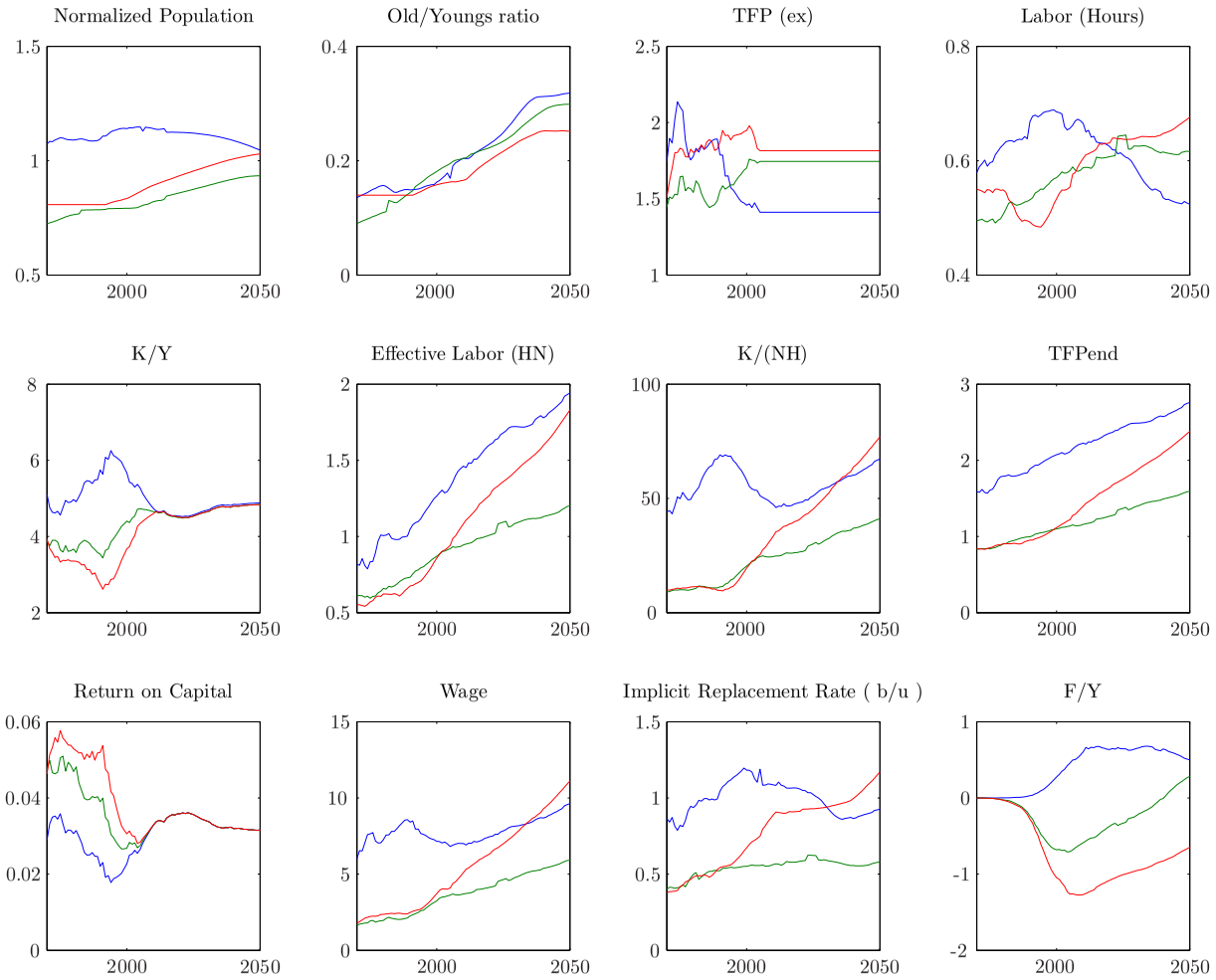
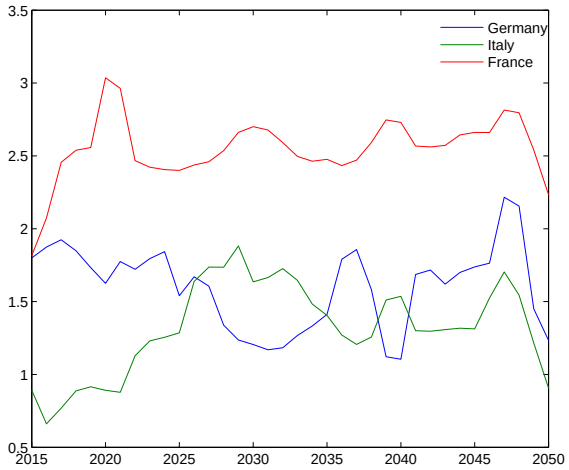


Figure 4: Open Economy Transition 1970-2010 and Projection (Blue: Germany; Green: Italy; Red: France)

Figure 5: GDP growth rates in open economy



5 Thought experiments

In this section, we describe possible interventions oriented to achieving more homogeneous public finance conditions and human capital formation processes among countries. In particular, we focus on two kinds of intervention: fiscal policy measures aimed at redirecting the capital allocation from financial to real capital stock, in countries with less capital-intensive processes, and an increase in the human capital formation process in countries where this is scarce, i.e. Italy.

We focus first on fiscal policy which would affect each country's relative financial and real capital allocation to achieve more similar growth processes and alleviate strong secular stagnation in aging and less human capitalized countries. In light of European economic policy oriented to more homogeneous public finance conditions among countries, we analyze the (internal and spillover) effects of fiscal consolidation and particularly reduction in the debt-to-GDP ratio, following six pack goals. We adjust the primary surplus through various channels (reduced social transfers, increased labor income tax, increased net-wealth tax). We also explore the effects of increasing net-wealth taxation in Italy aimed at increasing revenues to boost real capital investment.

In the second exercise we explore the effect of an increase in the rate of growth of human capital accumulation in Italy in order to reduce the gap with Germany and France.

6 Results

In this section, we discuss the results of our experiments (see Appendix A). First, we discuss the findings related to the decrease in public debt for Italy only, and then for Italy and France. Second, we focus on the effect of increased taxation on net wealth in Italy used to finance investment in real capital. Third, we show the positive outcome of increasing human capital in Italy. Finally, we show the results of a coordinated increase at the European level in net wealth taxation in order to finance public investment in countries with less capital accumulation. The results of our experiment are difficult to interpret since they reveal a complicated process of policy coordination.

6.1 Public debt reduction

Sections 6.1.1, 6.1.2, 6.1.3 and 6.1.4 describe different fiscal consolidation scenarios in countries with higher public debt-to-GDP ratios, namely Italy and France.

6.1.1 Reduction in Italy's public debt

Let us focus on the effects of the fiscal compact implemented in Italy without increasing taxation (Fig. 6-7). This implies that government will balance the budget via adjustments to the primary surplus (through social transfer changes). The reduction of public debt in Italy from 120 percent to 60 percent of GDP (in 30 years) allows for a reallocation of household saving from public debt assets to other assets and allows increased firm investment financing. This leads to higher capital accumulation, and correcting for over-financial accumulation in Italy. The increase in aggregate capital accumulation contributes to reducing the European interest rate (by 120 base points). Indeed, the decrease in Italy's public debt allows other countries to release funds to increase capital accumulation (spillover effects). The reduction in the rate of return leads to an increase in labor productivity which causes a decrease in the labor supply for all countries. A capital increase and labor supply reduction implies an increase in endogenous TFP that will boost GDP

growth. The positive effect of decreasing government debt interest payments in Italy seems to outweigh the negative impact of a reduction in foreign funds used to finance public spending.

Table 2: GDP growth rate deviation from baseline - Fiscal consolidation in Italy

	Germany	**Italy**	**France**
16-20	0.07	0.21	0.25
21-25	0.12	0.12	0.22
26-30	0.08	0.05	0.09
31-35	0.06	0.02	0.02
36-40	0.03	0.02	0.01
41-45	0.01	0.00	-0.04
46-50	-0.00	-0.02	-0.05

6.1.2 Simultaneous reduction in public debt in Italy and France

When the fiscal compact is implemented by Italy and France simultaneously [4] over the same time horizon (30 years), the effects on the rate of growth of GDP (in deviations from the baseline) are smaller for each country, compared to the case of consolidation implemented only in Italy. The relative bigger weight of France compared to Italy on the economies of GIF determines a reduction in German wealth as a result of a decreasing level French (and Italian) public debt to be financed (Fig. 8-9). Therefore, the decrease in German wealth counterbalances the total increase in wealth in France and Italy, keeping the real interest rate constant compared with the previous case of only Italian consolidation. This implies less capital-intensive production in each country, and lower positive effects on the public surplus (from the reduction in debt interest payments) compared to the case of Italian consolidation. The smaller increase in capital to effective labor stemming from the shock will imply lower but still positive GDP growth rate deviations from the baseline in all countries (given the positive effects of consolidation), and even negative growth rates in France after 2031.

[4] In this case we simulate a reduction from 95in 30 years for France.

Table 3: GDP growth rate deviation from baseline - Fiscal consolidation in Italy and France

	Germany	Italy	France
16-20	0.01	0.07	0.17
21-25	0.09	0.07	0.08
26-30	0.06	0.03	0.03
31-35	0.05	0.02	-0.01
36-40	0.02	0.02	-0.01
41-45	0.01	0.00	-0.03
46-50	-0.00	-0.01	-0.03

6.1.3 Reduction in public debt in Italy and France with increasing labor taxation

Let us assume that both Italy and France implement fiscal consolidation allowing for an increase in labor income taxation. This means that the fiscal budget will benefit from both a lower cost of government debt repayment and rising fiscal revenue from labor. Again, the reduction in French and Italian public debt enables Germany to decrease its wealth (previously used to fund foreign public debts) and simultaneously increase capital investment (given lower interest rates), partially financed by French and Italian wealth released by consolidation.

Labor income taxation causes a decrease in the labor supply in Italy and France, and increase in the labor supply in Germany. Also, Germany's public surplus will rise more than in Italy and France since it will be favored by the reduction in the interest rate with no negative effects of consolidation in terms of shortage of funds (Fig. 10-11). The higher the capital to effective labor ratio in Italy and France will provide the highest results in terms of GDP growth rate deviations from the baseline, compared to the fiscal consolidation scenarios proposed in sections 6.1.1 and 6.1.2.

Table 4: GDP growth rate deviation from baseline - Fiscal compact in Italy and France with increasing labor taxation

	Germany	Italy	France
16-20	-0.07	0.36	1.01
21-25	0.39	0.38	0.42
26-30	0.26	0.19	0.15
31-35	0.19	0.10	-0.01
36-40	0.10	0.09	-0.01
41-45	0.05	0.03	-0.12
46-50	-0.00	-0.04	-0.14

6.1.4 Reduction in public debt in Italy and France with increasing net-wealth taxation

To be continued...

6.2 Increasing taxation on net wealth in Italy

Figures 12 and 13 show the effects of an increase in taxation on net wealth in Italy (flat tax scheme from 0 to 0.2 percent). The Italian government uses the increased fiscal revenues from wealth to give incentives to firms to increase capital investment allowing for capital investment transfers to the same amount as collected revenues. This means that foreign wealth must increase in order to finance the demand for investment goods in Italy. As a result, the relative higher weight of France and Germany leads overall wealth to increase, and the world interest rate to decrease. Labor productivity increases implying a lower labor supply which lowers labor income revenues and social transfers. The increased capital to effective labor ratio will boost growth, and hence labor in the medium and long run. Table 6.2 shows higher positive GDP growth rates for Italy compared to the baseline.

In the progressive scheme we use a tax rate triangular distribution centered around the retirement age. This means that the tax rate increases linearly from zero to 0.4 percent and decreases again to zero for as long as the individual cohort survives. The increase in progressive net wealth taxation will increase the effects on GDP growth rates (Fig. 14-15) as a result of stronger wealth reductions in Italy which will have a bigger impact on the interest rate and on capital accumulation.

Table 5: GDP growth rate deviation from baseline - τ_k flat

	Germany	**Italy**	**France**
16-20	0.11	-0.08	0.36
21-25	0.13	0.28	0.23
26-30	0.08	0.16	0.08
31-35	0.05	0.11	-0.00
36-40	0.02	0.09	-0.01
41-45	0.00	0.06	-0.05
46-50	-0.01	0.01	-0.06

Table 6: GDP growth rate deviation from baseline - τ_k progressive

	Germany	Italy	France
16-20	0.12	-0.23	0.37
21-25	0.11	0.32	0.19
26-30	0.07	0.20	0.06
31-35	0.04	0.15	-0.02
36-40	0.01	0.11	-0.01
41-45	-0.00	0.07	-0.05
46-50	-0.01	0.02	-0.05

6.3 Increasing human capital formation in Italy

In this section, we evaluate the effects of an increase in human capital in Italy such that the long-run human capital growth rate goes from 0.8 percent (baseline) to 1 percent. This allows the gap with Germany and France (where human capital grows at around 1.4 percent) to be reduced. We assume that the increase in Italian human capital is financed completely by a reduction in the Italian primary surplus (Figure 16).

In the first years after the shock, higher human capital leads to a decrease in labor productivity and wages, and to a reduction in working hours. This will imply an adjustment to the primary surplus via a reduction in social transfers. However, this trend is reversed in the medium and long-run. Increasing human capital allows for long-run growth via increasing returns to scale which determine higher labor supply, real capital, and primary surplus. The increase in capital accumulation lowers the rate of return and the incentive to save. Therefore, capital investment in Italy is financed by increasing foreign financial wealth. The increase in the Gdp growth rate is huge because the increase in productivity is permanent and perfeclty foreseen by the agents. Therefore consumption increases sharply[5] while transfer could adjust slowly.

Table 7: GDP growth rate deviation from baseline - decreasing Italian primary surplus

	Germany	Italy	France
16-20	0.04	3.36	0.21
21-25	0.16	1.79	0.21
26-30	0.16	0.99	0.25
31-35	-0.02	0.73	0.04
36-40	0.02	0.51	0.10
41-45	-0.04	0.46	-0.02
46-50	-0.05	0.47	0.00

[5]In this case we recommend to take into account this hypothesis such as the reader should postpone the effect on growth as agents should react in reality more slowly.

7 Conclusions

The analysis shows the effects of the interaction between aging, open capital markets, and endogenous growth in Germany, France, and Italy. Demographic trends and human capital endowments provide for different rates of long-run growth and financial sustainability in different countries within an integrated economic area. We showed that the model is able to replicate the financial specialization explained by the endogenous technological accumulation process that gives leadership to Germany as a net financial investor. In this case, aging would lead to a reduced rate of growth for Germany. At the same time, Italy was shown to be lagging behind due to slower human capital formation compared to the other two countries. During capital market opening Italy specialized in financial capital accumulation, and therefore reduced the accumulation of physical capital which also reduced the level of endogenous technological innovation. Finally, France, thanks to its younger population structure and relative high human capital endowment, showed a speeded up growth process which results in potential sustained high GDP growth. In order to reduce the growth path gaps among countries, we explored the effects of fiscal policy focusing on fiscal consolidation and net wealth taxation together with increased human capital and public investment interventions. We show a positive effect on potential growth due to public debt consolidation in particular, if Italy is the only country implementing it. If France also participates in the consolidation process, this crowds out the positive effect since an overall reduction in debt would require a bigger decrease in overall savings. An induced human capital growth rate in Italy would affect the capital accumulation correcting endogenously the rate of accumulation of financial assets as desired and boosting to Gdp growth rate. Similarly, a public investment policy in Italy financed by net wealth taxation would foster growth in the whole economy and would provide positive spillover effects. Finally, the analysis provide a robust evidence of an expected rising trend in the next decades for interest rates due mainly to the pronounced aging process of Germany.

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A Figures

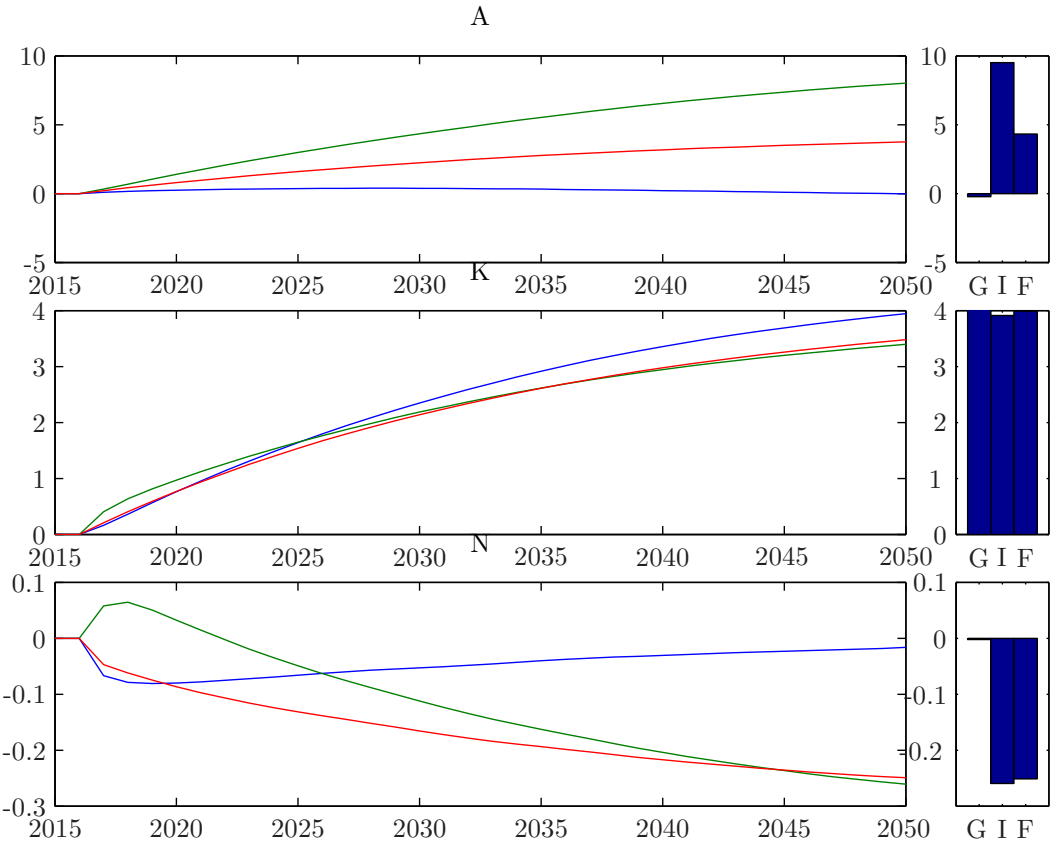

Figure 6: Fiscal Compact for Italy: Public Debt consolidation (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

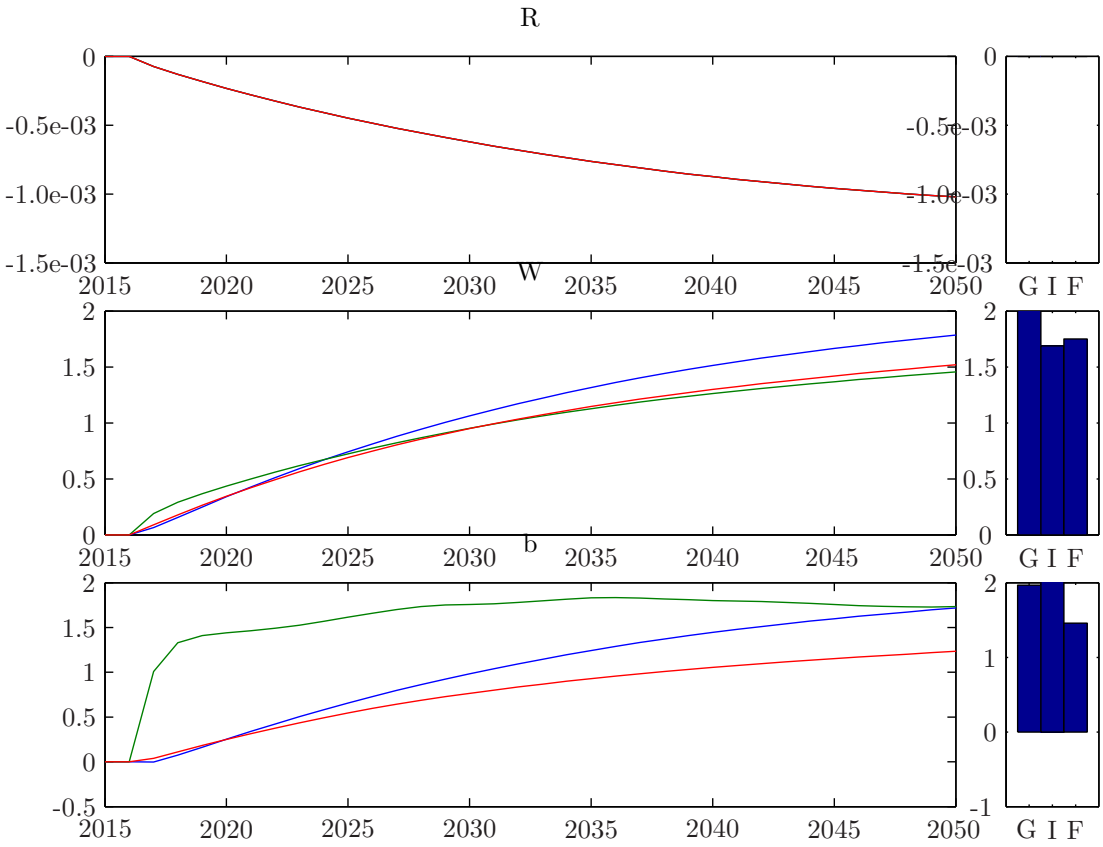

Figure 7: Fiscal Compact for Italy: Public Debt consolidation (Blue: Germany; Green: Italy; Red: France). R: return rate on capital. W: wage. b: social transfers.

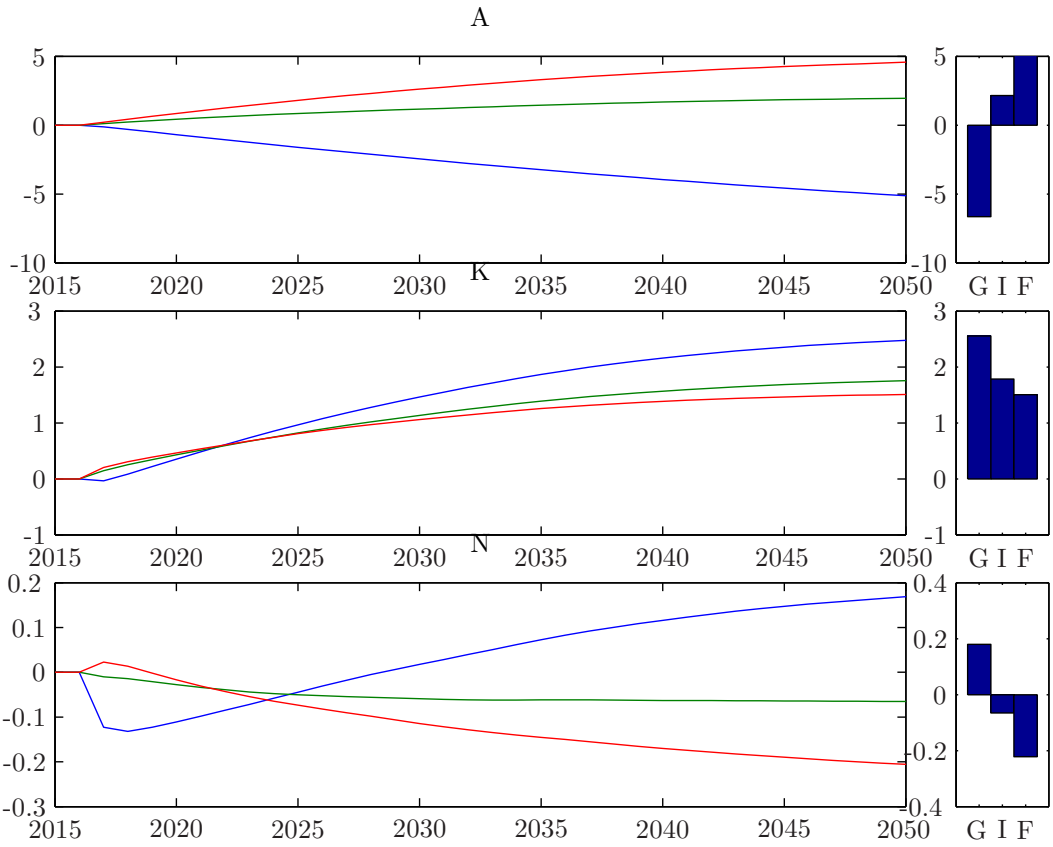

Figure 8: Fiscal Compact for Italy and France: Public Debt consolidation (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

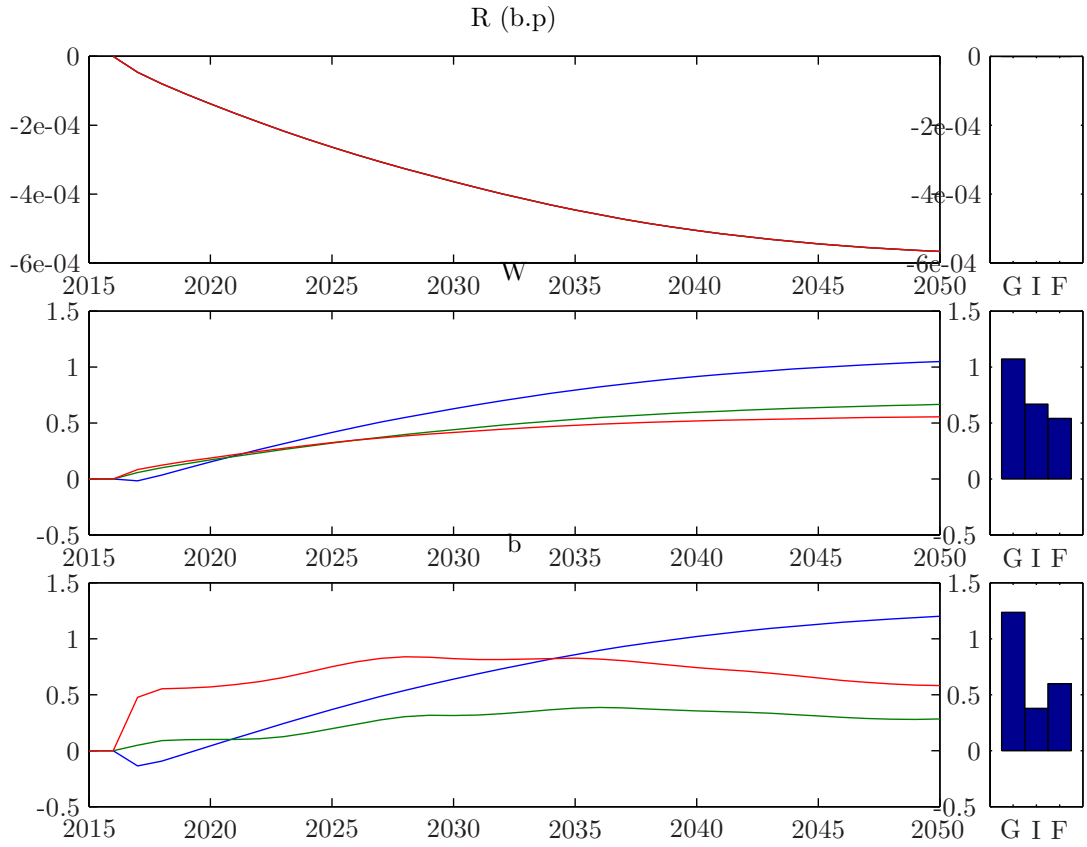

Figure 9: Fiscal Compact for Italy and France: Public Debt consolidation (Blue: Germany; Green: Italy; Red: France). R: return rate on capital. W: wage. b: social transfers.

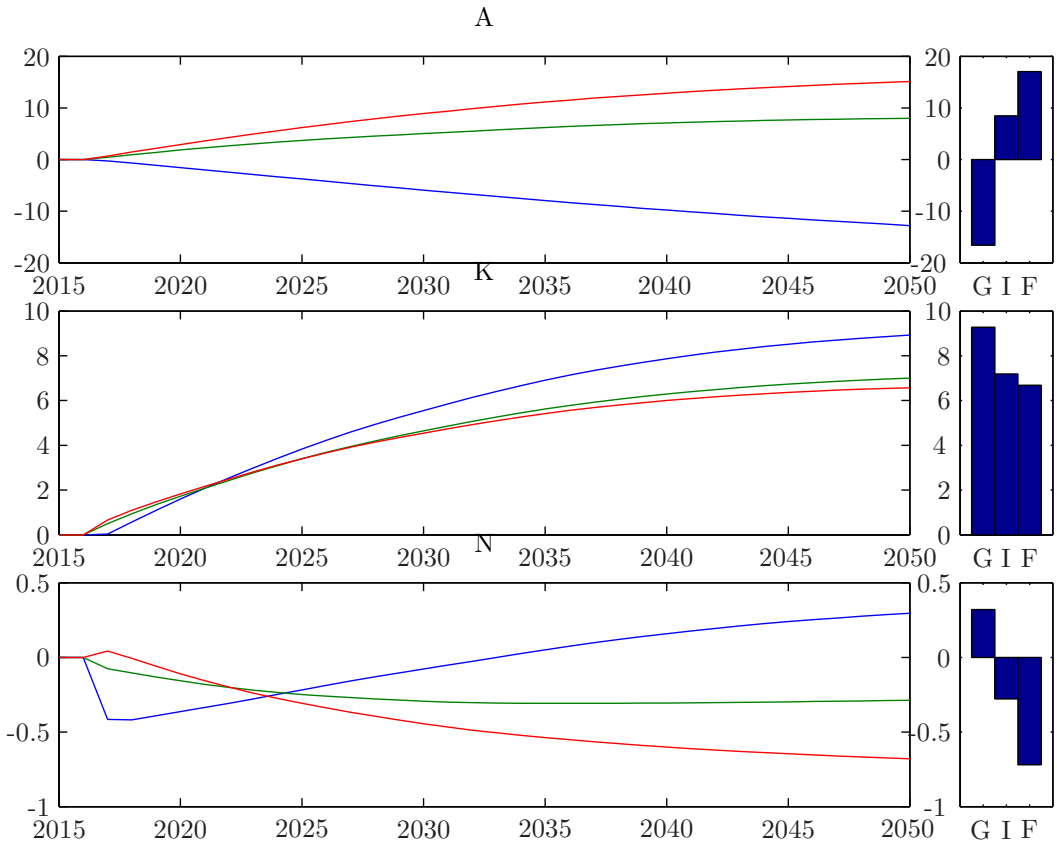

Figure 10: Fiscal Compact for Italy and France: Public Debt consolidation through labor taxation (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

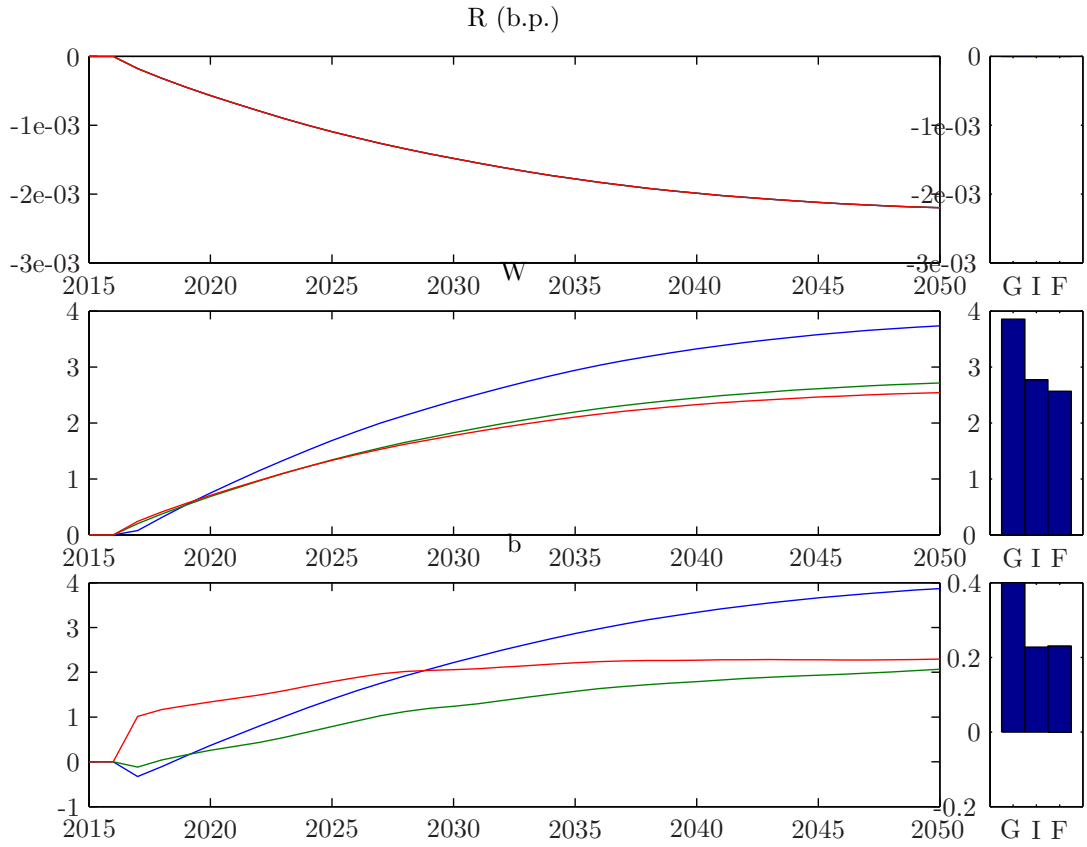

Figure 11: Fiscal Compact for Italy and France: Public Debt consolidation through labor taxation (Blue: Germany; Green: Italy; Red: France). R: return rate on capital. W: wage. b: social transfers.

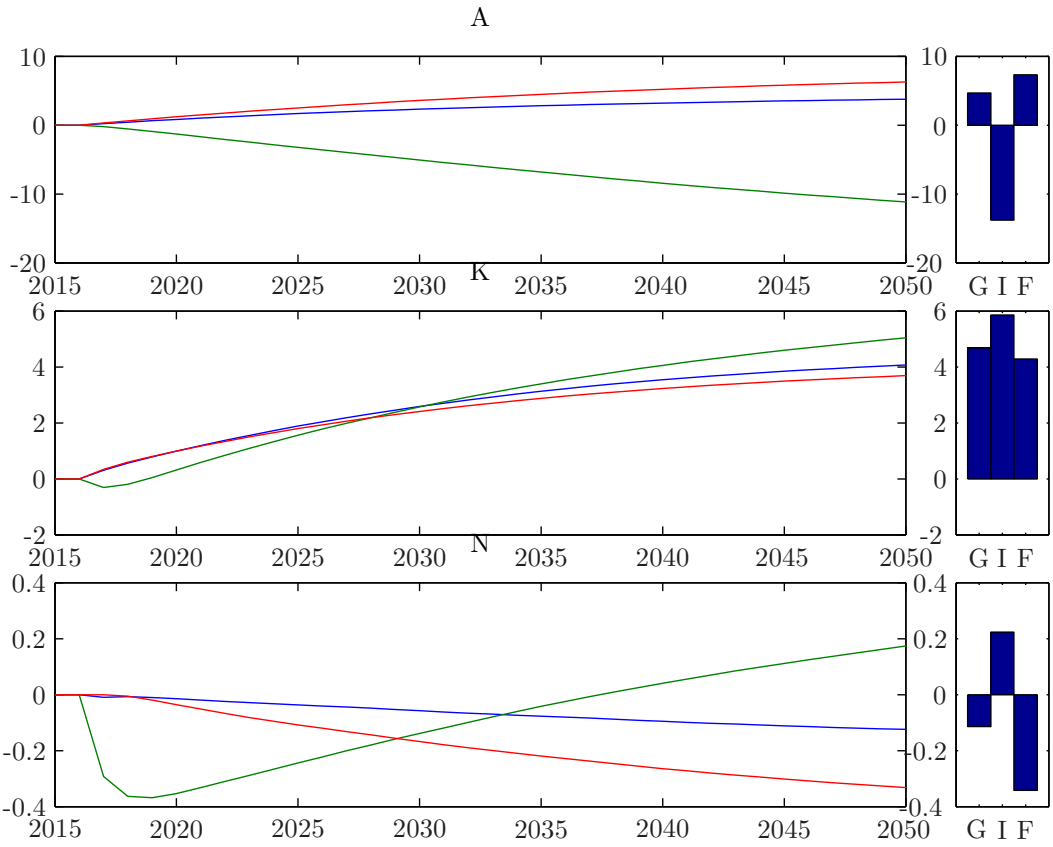

Figure 12: Wealth Taxation on Italy and Public investment: Flat scheme taxation (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

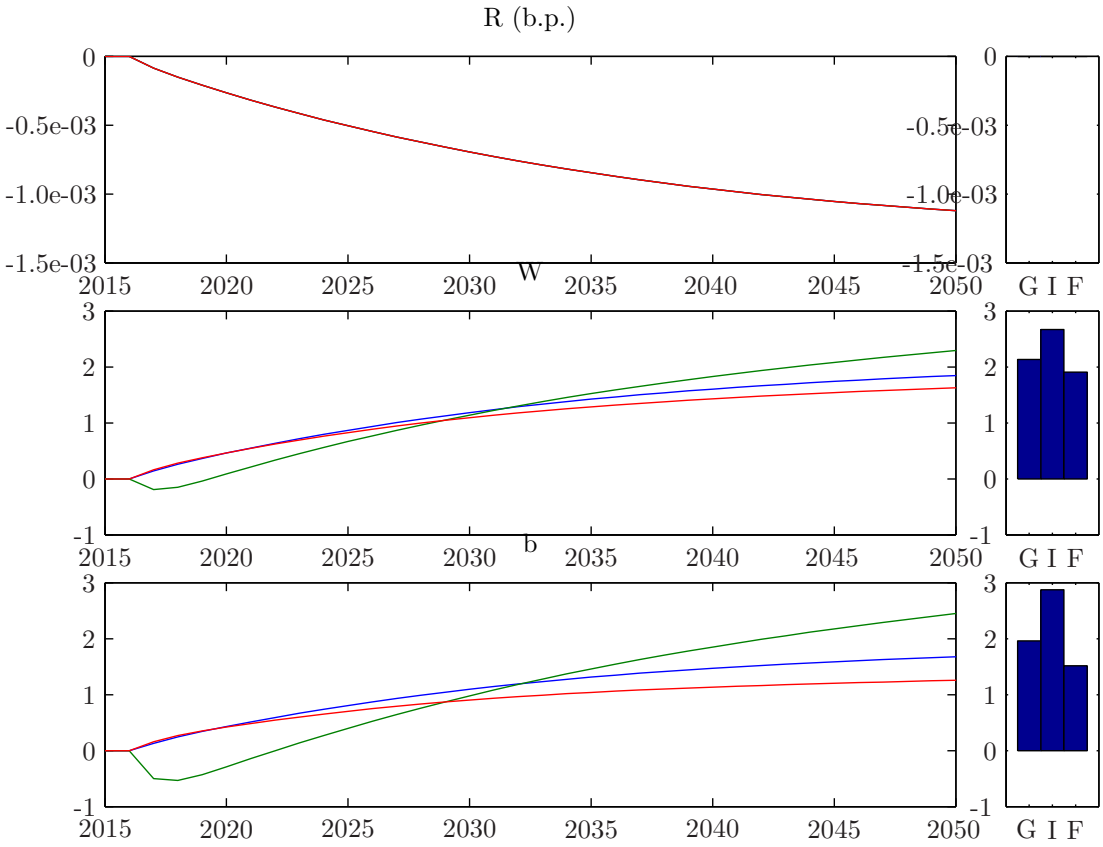

Figure 13: Wealth Taxation on Italy and Public investment: Flat scheme taxation (Blue: Germany; Green: Italy; Red: France). R: return rate on capital. W: wage. b: social transfers.

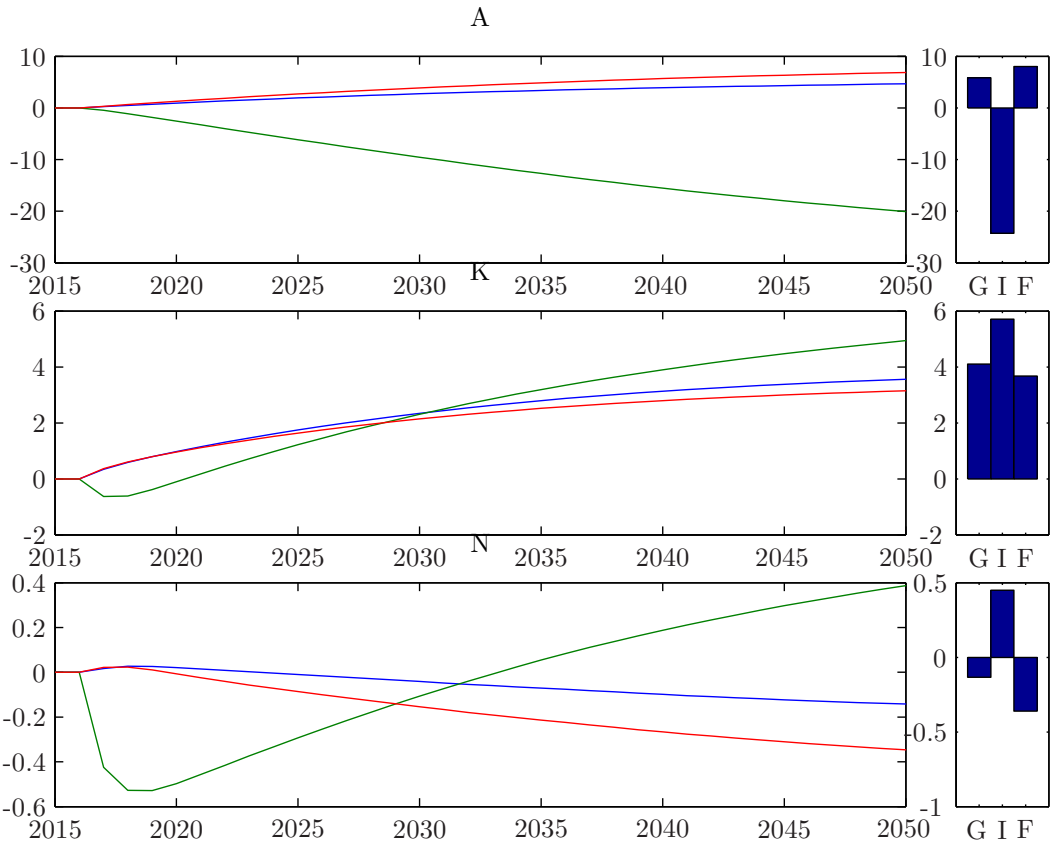

Figure 14: Wealth Taxation on Italy and Public investment: Progressive scheme taxation (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

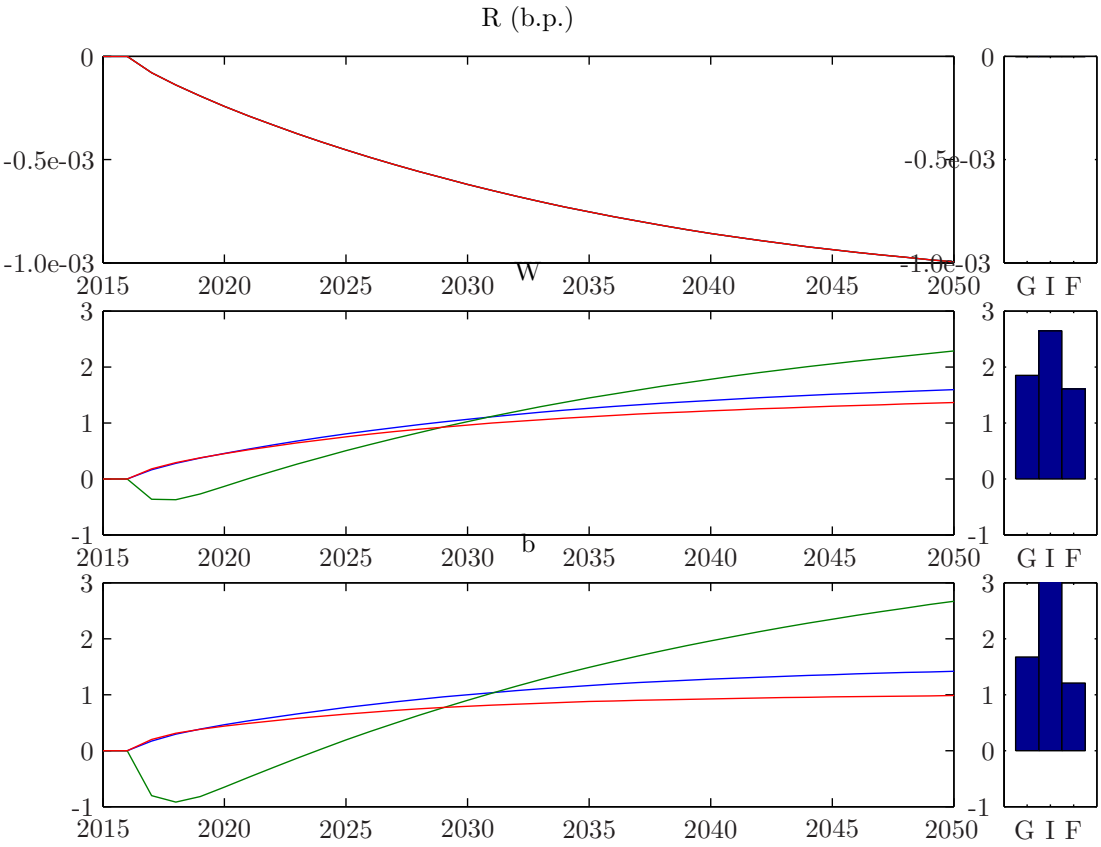

Figure 15: Wealth Taxation on Italy and Public investment: Progressive scheme taxation (Blue: Germany; Green: Italy; Red: France). R: return rate on capital. W: wage. b: social transfers.

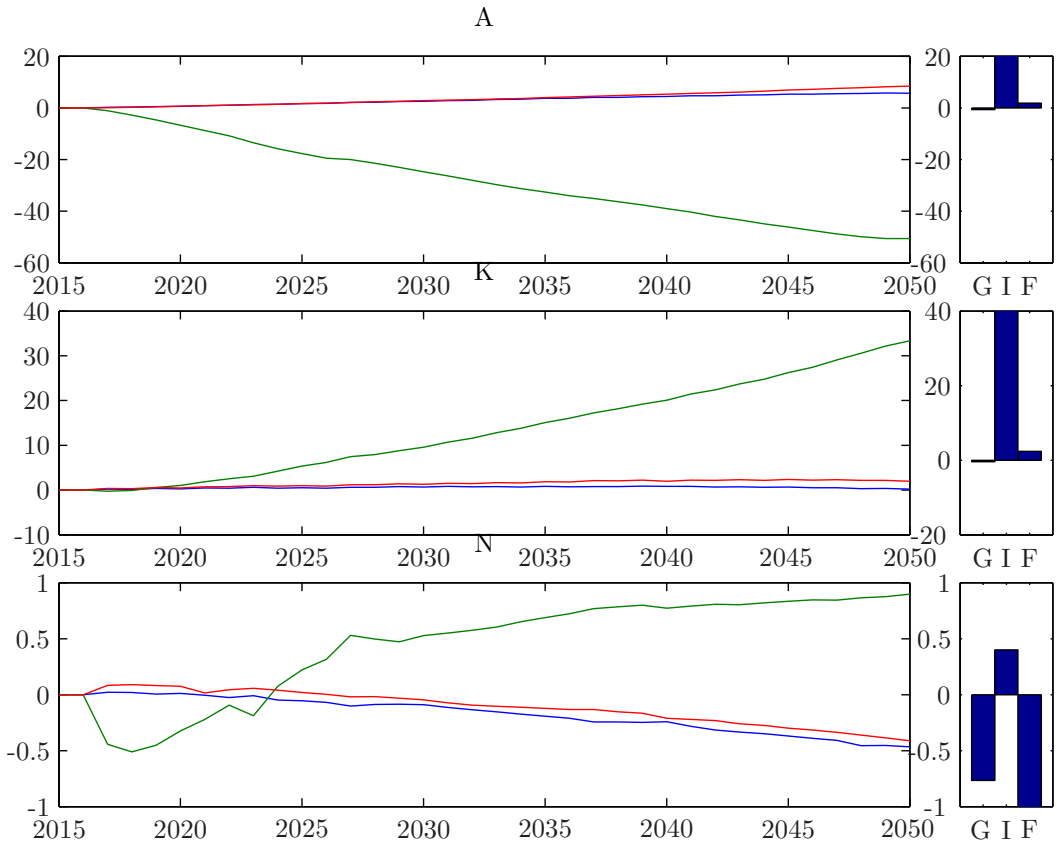

Figure 16: Increase in human capital in Italy via decreasing primary surplus (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

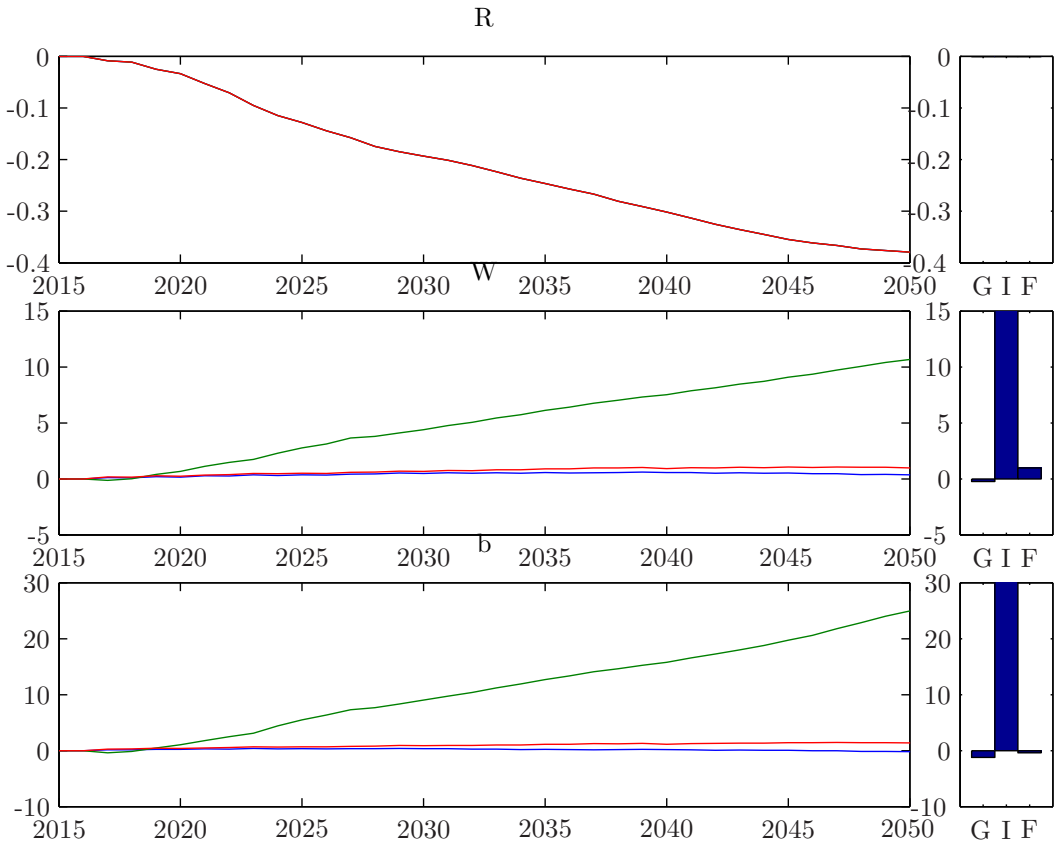

Figure 17: Increase in human capital in Italy via decreasing primary surplus (Blue: Germany; Green: Italy; Red: France). R: return rate on capital. W: wage. b: social transfers.

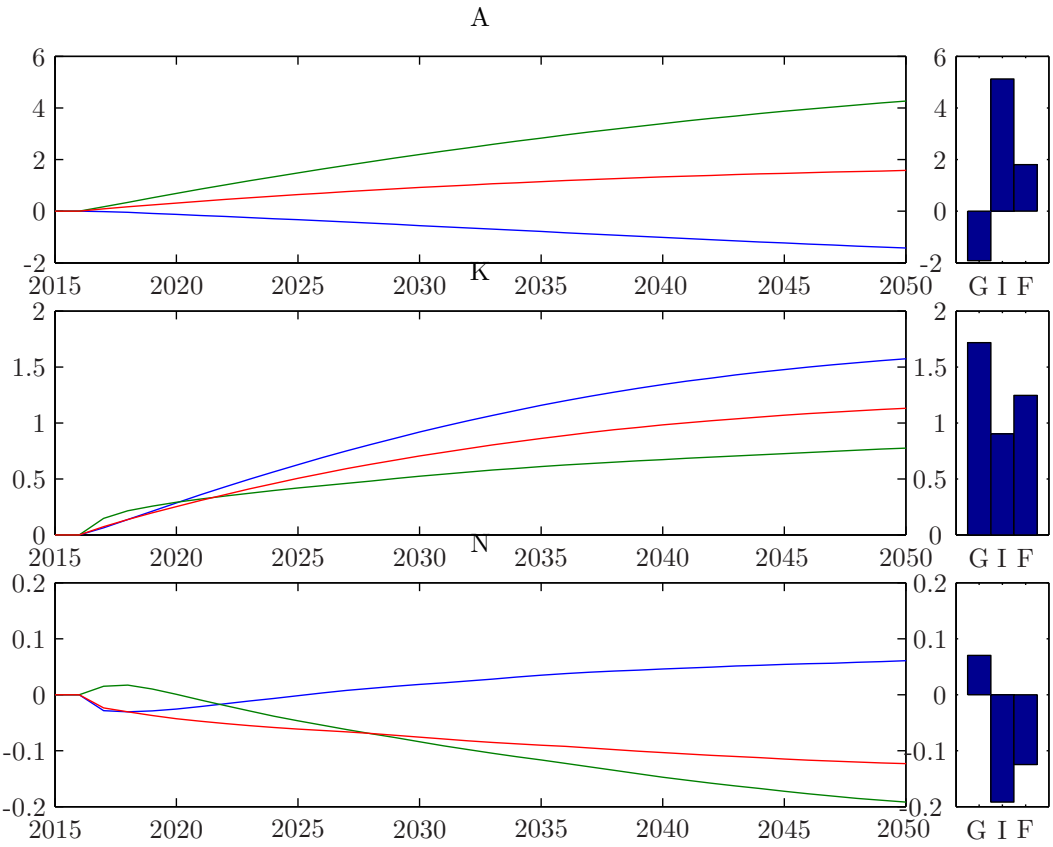

Figure 18: Wealth Taxation on GIF and Public investment (Blue: Germany; Green: Italy; Red: France). A: Wealth. K: Capital stock. N: Labor supply.

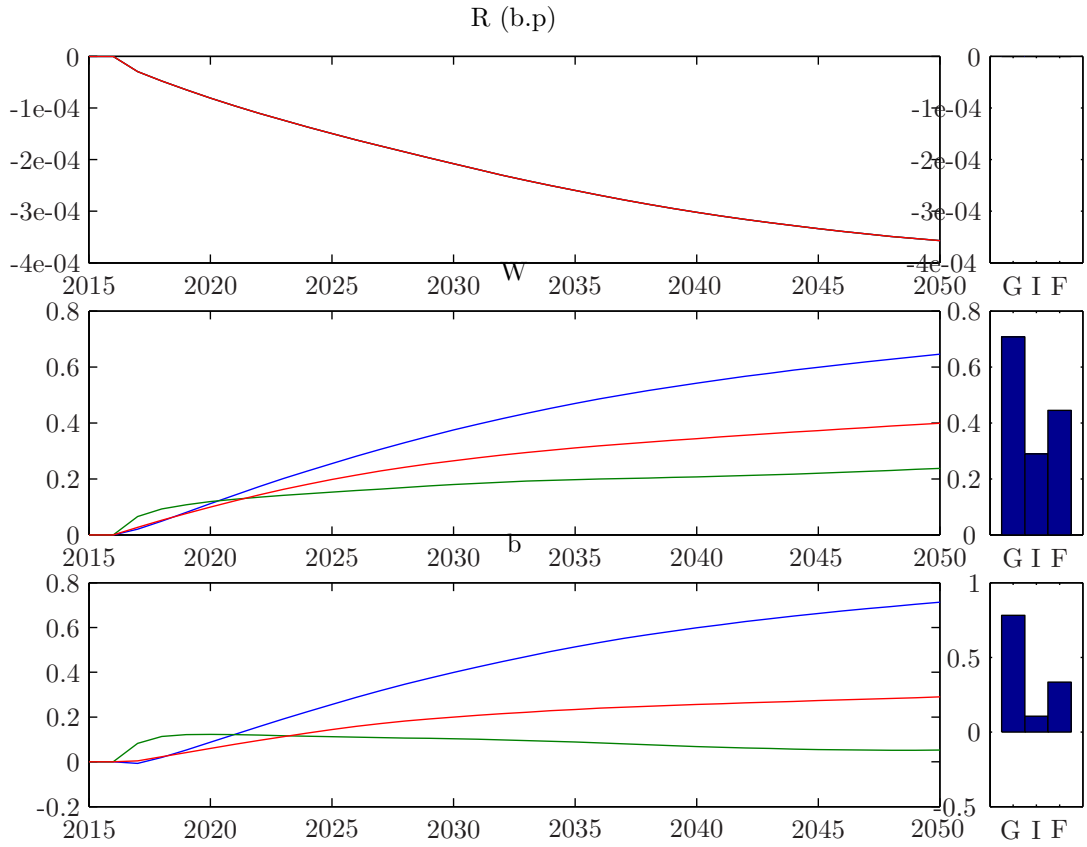

Figure 19: Wealth Taxation on GIF and Public investment. R: return rate on capital (Blue: Germany; Green: Italy; Red: France). W: wage. b: social transfers.