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Political complements in the welfare state: Health care and social security ☆

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Abstract

All OECD countries target a large majority of their welfare spending to the elderly, through public pensions and health care programs. Spending in both programs has largely increased in the past decades — often more than the share of elderly in the population. We suggest that these phenomena may be due to political complementarities between these two transfer programs. We show that these two programs may coexist, because public health care may increase the political constituency in favor of social security, and vice-versa. Specifically, public health decreases the absolute longevity differential between low and high-income individuals, therefore rising the retirement period and the total pension benefits of the former relatively to the latter. This effect increases the political support for social security among the low-income young. We show that in a political equilibrium of a two-dimensional majoritarian election, a voting majority of low-income young and retirees supports a large welfare state; the composition between public health and social security is determined by intermediate (median) income types, who favor the contemporaneous existence of these two programs, since public health increases their longevity enough to make social security more attractive. Technological improvements in health care strengthens this complementarity and lead to more welfare spending.

JEL classification: H53; H55; D72
Keywords: Intergenerational transfer; Endogenous longevity; Subgame perfect structure induced equilibrium

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1. Introduction

In all OECD countries, the two major welfare state programs – public pensions and health care – target mainly the elderly. Unfunded pension systems use current contributions from the workers to finance current pension benefits to the retirees. Public health care programs may instead be financed through general taxation or earmarked labor taxes, but provide most of their benefits to the elderly. As a result, in the US, people aged 65 to 74 receive five times more benefits than individuals with less than 64 years (see Hagist and Kotlikoff, 2005). Similar, yet less extreme, patterns apply to other OECD countries. Furthermore, in the last few decades social security and public health care spending has dramatically increased in all developed economies. Aging has typically be identified as the major culprit of this spectacular raise in public spending, due to the increase in the share of beneficiary from these programs. Yet, social security and health care spending has often increased more than the share of elderly in the population, thereby suggesting that pension and health care benefits per each elderly individual have also increased.

Public provision of health care and pension transfers have traditionally been justified because of inefficiency in some relevant markets – such as annuity and private health care – due to asymmetric information. Recently, the health care literature has emphasized the relevance of technological progress, and the adoption of new, more expensive medical treatments (see Newhouse, 1992) to explain the raise in health spending. Yet, why are these new technologies so massively used in spite of their cost? In a recent paper, Hall and Jones (2004) argue that health care is a superior good: as individuals get richer they choose to spend a larger proportion of their income on health care. Policy-makers are thus merely adjusting public health spending to individual preferences. Analyzing the political support to social security and medicare, Bohn (1999) forecasts a further increase in spending driven by the change in the age profile of the electors. Galasso and Profeta (2004) concentrate on social security, and reach as similar conclusions: aging will lead to a further increase in the share of social security spending over GDP.[1]

This paper presents an additional explanation of the contemporaneous existence of these two large welfare state programs – health care and social security – mainly targeted to the elderly, based on a notion of political complementarity among welfare programs.

We show that more health care may increase the political constituency in favor of social security, and viceversa. There may be several channels of political complementarities, as one program may modify some relevant characteristics of the voters — thereby changing their preferences over the other welfare program. Here, we concentrate on how health care policies may affect the redistributiveness of social security.

The seed of this intuition was in Philipson and Becker (1998), who argued that social security induces the elderly to increase their private investment in health care, because the existence of an annuity – the old age pension – raises the value of longevity. Here, we identify a new link that goes from (public) health care to social security. Expenditure in public health care increases longevity in a non-linear way, since its effect tends to be larger among low-income individuals than among well-off people. However, richer individuals tend to live longer. Thus, for a given income distribution, expenditure in public health contributes to decrease the longevity differential between rich and poor individuals. As a result, the retirement period, and thus the total pension benefits, increases more for low-income than for high-income individuals, therefore rising the returns on social security for the low-income workers, as opposed to high-income ones.[2]

The main contribution of the paper is to show that, for a sensible – yet stylized – representation of the two separate programs, some political complementarity between social security and public health care emerges. This political complementarity justifies the use of two welfare programs to transfer resources to the elderly and helps to explain the large government spending in health care and social security. Social security and public health care are sustained as a politico-economic equilibrium outcome of a majoritarian voting game. A voting majority of low-income young and all retirees supports a large welfare state, as in Tabellini (2000) and in Conde-Ruiz and Galasso (2005). Its composition between public health care and social security is determined by intermediate (median) income types, who favor a combination of the two programs, since public health care increases their longevity enough to make social security more attractive. Additionally, we show that an improvement in the health care technology that increases the effectiveness of public health care in raising longevity strengthens this political complementarity and thus increases welfare spending.

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[1] See Galasso (2006) for a detailed discussion of the political economy of social security.

[2] Borck (2003) also emphasizes the importance of the link between income and longevity in pension policy decisions.

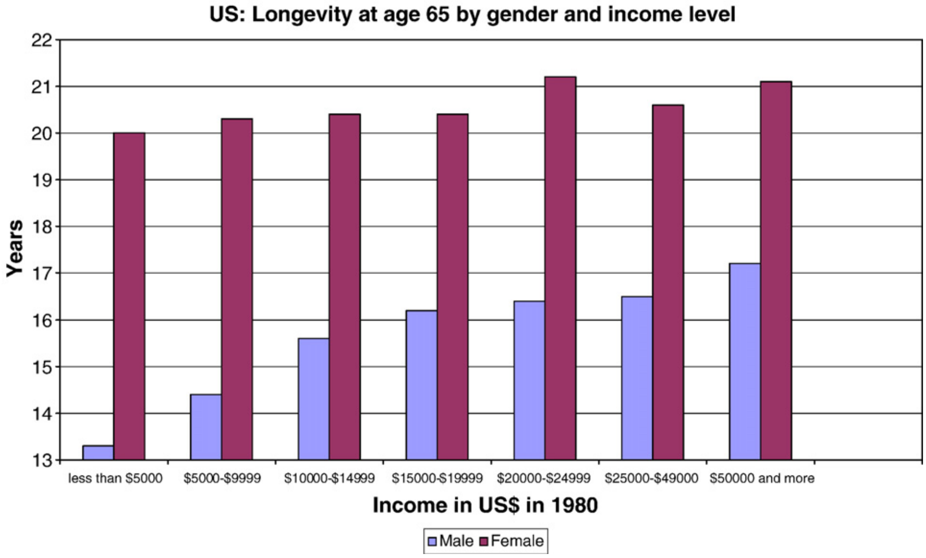

Fig. 1.

Our theoretical model is built around three crucial elements. First, income has a protective effect on health — hence, high-income individuals live longer. This effect gives raise to a health “gradient”: income inequality is associated with health inequality. Second, health care improves the quality of life and increases longevity. In particular, the increase in longevity due to public health care is stronger for low-income than for high-income individuals — thereby reducing the degree of health inequality due to income. Third, both social security and health care entail an element of intragenerational redistribution, since contributions to both programs are proportional to labor income, while benefits – i.e., pension transfers and health care services – are assumed to be constant. The combination of these three elements is critical to explain the political support for health care and social security among low-income individuals. The empirical counterpart of these building blocks of the theoretical model are presented in detail in Section 2.

We introduce a dynamically efficient overlapping generation economy with storage technology. Individuals differ in their income, and therefore in their longevity. Agents value their old age consumption and total health care, which is provided publicly and privately. Private health care is more efficient in increasing the quality of life, and therefore in providing direct utility. Public health care is less efficient in rising the quality of life, but it affects longevity. This effect on longevity is non-linear, and is stronger for low-income agents.

The welfare state collects a proportional income tax on the young, which finances public health care expenditure to the old and social security transfers. Public health care is available in equal amount to every elderly person at the beginning of her old age, whereas the unfunded social security system pays out a lump sum pension during the entire retirement period, i.e., an annuity.

The size of the welfare state and its composition between the two systems are determined in a two-dimensional majority voting game by all agents alive at every election. These types of voting games display two critical features. First, because of the multidimensionality of the issue space, the existence of a Condorcet winner of the majority voting game is not guaranteed. Second, if an equilibrium exists, in absence of a commitment device over future policies, young voters have no incentive to support any intergenerational transfer scheme.[3] To deal with these characteristics of the game, as Conde-Ruiz and Galasso (2003, 2005), we combine the concept of structure induced equilibrium, see Shepsle (1979) and Persson and Tabellini (2000), with the notion of subgame perfection.

The paper proceeds as follows: Section 2 presents some empirical evidence in support of the crucial assumptions underlying the theoretical model, which is then described in Section 3. Section 4 discusses the voting game, and the equilibrium concept, while Section 5 characterizes the politico-economic equilibria. Section 6 analyzes the effects on

[3] Recent examples of dynamic majoritarian voting games are in Krussell et al. (1997), Conde-Ruiz and Galasso (2003, 2005) and Hassler et al. (2003).

the welfare spending of an improvement in the health care technology. Section 7 concludes. All proofs are in the Appendix.

2. Some empirical evidence on health “gradient” and redistribution

This section analyzes the empirical evidence – based on a review of the large existing health and epidemiological literature – on the crucial assumptions that constitute the building blocks of the theoretical model presented in the next section. We dedicate most of the section to discuss the existence of a health gradient — i.e., a positive, non-linear relation between health and income; to provide some evidence on the evolution of this gradient over time and on the determinants of this evolution; and to examine the distinctive roles of public and private health care. Finally, we provide some evidence on the degree of redistributiveness of public health care and social security.

2.1. The gradient

A well established fact in the health literature is that high-income individuals live longer. A positive correlation exists between different measures of socio-economic status – such as income, wealth or education – and health status, measured for instance as self-reported health quality or longevity. This health inequality by income levels is presented at Fig. 1, which uses data from Rogot et al. (1992) to show the longevity at age 65 for males and females in the US according to their family income. The difference by income levels are striking:[4] even at age 65, a male in the highest income group is still expected to live four years more than a 65 year old male in the lowest income group; for females, who overall enjoy higher longevity than males, the difference is above one year. In other words, a male in the highest income group retiring at 65 has an expected length of retirement (17.2 years) which is almost 30% longer than a 65 years old male in the lowest income group (13.2 years).

Preston (1975) showed that a similar gradient exists also across countries, with medium to high-income countries enjoying a larger average longevity at birth than low-income countries. He also found the relation between income and health to be non-linear, with the gradient being steep across low-income countries and almost flat among high-income countries. This concavity in the relation between income and health emerges also at the individual level. Backlund et al. (1999) report large differences in mortality according to income across low socio-economic groups but little role for income among high socio-economic groups.

While the existence of a positive association between income and longevity is well established, some controversy remains on the direction of causality. Does the gradient stem from health affecting individual working opportunities – and hence income – or from income providing a protective effect on health? A broad overview of the existing literature suggests that both directions of causality are indeed at work (see Smith, 1999); for the purpose of this paper, however, we concentrate on the impact of income – or more generally socio-economic status – on health conditions.

Deaton (2002, 2003) and Cutler et al. (2006) provide a comprehensive review of the main determinants of health inequality discussed in the literature. A common argument to explain the positive impact of socio-economic status on health is that richer, higher educated individuals have better access to health care, both because they devote more resources to getting care and because they have a better understanding of how the health care system works. Differences in nutrition and in housing conditions may also help to explain part of the gradient, in particular the large health inequality among the poorest. Poor nutrition has a particularly strong impact during pregnancy with long lasting health effects in adulthood (see Case et al., 2002). The relevance of this “fetal programming” may also explain the transmission of poor health within low-income families. Socio-economic differences, especially education, may affect the individuals’ health related behavior, such as smoking. For instance, after the initial warning by the General Surgeon on the risk of smoking in the 60s, high-income and more educated individuals have been quicker at quitting smoking. Interestingly, some studies (most notably the Whitehall studies in the UK, see Deaton, 2002, for a review) have identified psycho-social factors as a source of health inequality. According to this strand of literature, low relative social status and manual occupations create stressful situations. The build up of this “allostatic load” due to stress is a cause of deterioration in health status, which is more common among low socio-economic classes.

[4] At age 45, this difference is respectively eight years among males and four among females.

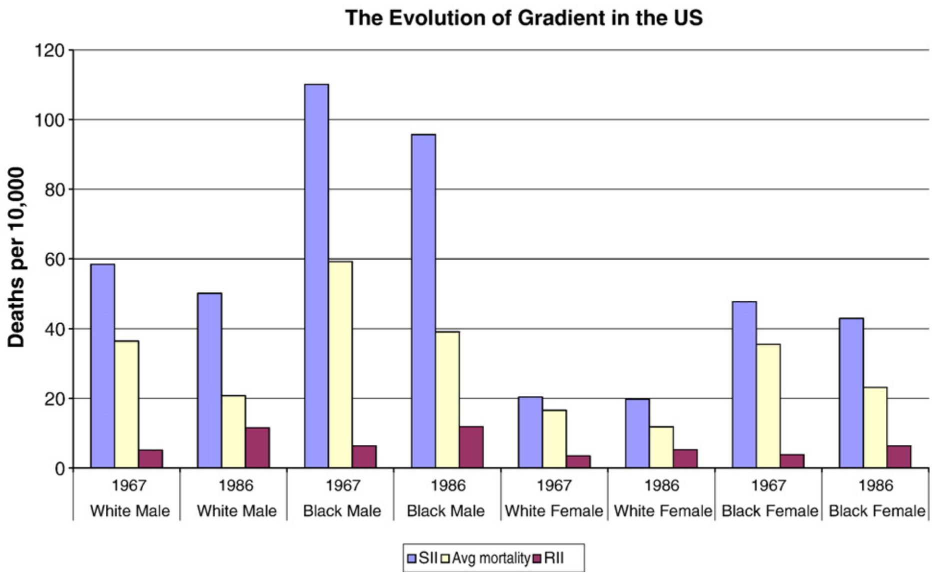

Fig. 2.

In a nutshell, although the exact magnitude of the different determinants of the gradient is still controversial, occupation related stress, differential use of health knowledge and health care technology certainly play a crucial role in generating health inequality (Cutler et al., 2006).

2.2. The evolution of the gradient

The health literature (see Wilmoth and Dennis, 2006) has largely studied the evolution of the mortality rates over time. While mortality rates have typically decreased for all socio-economic groups, the magnitude of this effect has differed. Relative mortality differences – measured as the ratio between mortality rates at low and high-income levels – have indeed widened over the last three decades, whereas absolute mortality differences – measured as the absolute differences between mortality rates at low and high-income levels – have decreased. Fig. 2, constructed using data from Schalick et al. (2000), summarizes these findings. The relative index of (health) inequality (RII) increased in all four groups used in Schalick's study (black females, black males, white females and white males), hence suggesting that the reduction in mortality rates was proportionally higher among high-income individuals. However, the slope index of (health) inequality (SII) dropped in all groups — thus implying that the absolute difference in mortality rate has instead decreased.[5] Cutler and Richardson (1998) reach similar results, using an alternative measure of health – the health capital – that combines the monetary value of longevity and health quality. According to their estimates, the gap in health for persons over 65 narrowed between 1970 and 1990, since the value of the health capital has increased by \$168,000 for a 65 years old who was below the poverty line, and by \$145,000 for an equally old individual above the poverty line.

To appreciate the implication of this pattern of widening relative and shrinking absolute mortality differences for the theoretical model of the next section, it is useful to define the (age specific) survival probability as $\delta_{i,t}=1-v_{i,t}$, where v is the mortality rate, t refers to time and i to the socio-economic group. In other words, given a population – normalized to one – of individuals of a certain age, a proportion v will die whereas a proportion δ will survive until the next period. The findings on the evolution of the absolute and relative mortality differences in Schalick et al. (2000), shown in Fig. 2, can be summarized respectively as follows:

$$\begin{aligned} &v_{P,t+1}-v_{R,t+1}<v_{P,t}-v_{R,t} \\ &v_{P,t+1}/v_{R,t+1}>v_{P,t}/v_{R,t} \end{aligned} \tag{2.1}$$

[5] Mackenbach et al. (2003) find similar patterns in Western European countries.

where P and R refer to poor and rich socio-economic groups. It is straightforward to see that the above equations imply a reduction in the absolute longevity difference

$$\delta_{R,t+1} - \delta_{P,t+1} < \delta_{R,t} - \delta_{P,t}, \tag{2.2}$$

and also in the relative longevity difference

$$\delta_{R,t+1} / \delta_{P,t+1} < \delta_{R,t} / \delta_{P,t}. \tag{2.3}$$

The longevity function postulated in the theoretical model of the next section will capture these features.

2.3. The determinants of the evolution

The evolution of the gradient described at Fig. 2 has emerged during a period of spectacular reduction in the mortality rate, which has led to a raise in life expectancy at birth in the US from 47.3 years in 1900 to 77.5 in 2003. The main characteristics of this drop in mortality have changed over time (see Cutler and Richardson, 1997, 1998). Until 1960, this process was mainly driven by a drop in infant mortality, but since then the reduction in old age mortality has become predominant. In fact, from 1900 to 1960, life expectancy at birth in the US increased by almost twenty-two years, but longevity at age 65 increased only by less than three years, whereas from 1960 to 2003 longevity at birth increased by almost eight years, and life expectancy at age 65 by four.

Fig. 3 uses data from the US Department of Health and Human Services to identify the leading causes of this large reduction in old age mortality. Lower mortality from cardiovascular diseases, which has decreased by 3% annually since the 60s, nearly single-handed delivered this trend of increased life expectancy.

Several explanations of the reduction in mortality among the elderly – in particular, from cardiovascular diseases – that are present in the epidemiological literature highlight the prominent role of medical care (see Costa, 2005, for a review). In particular, Cutler et al. (1999) estimate that medical improvements in primary prevention, acute management and secondary prevention account for nearly 50% of the reduction in mortality from heart diseases. Matching results of clinical trials to actual mortality declines, Cutler (2004) attributes two-thirds of the drop in cardiovascular disease mortality to medical advances; the other major factor being reduction in smoking. Comparisons of mortality rates from conditions amenable to medical interventions in Western and Eastern Europe and studies on the health care system efficiency after the German unification also support the relevance of medical care in reducing mortality (see Costa, 2005).

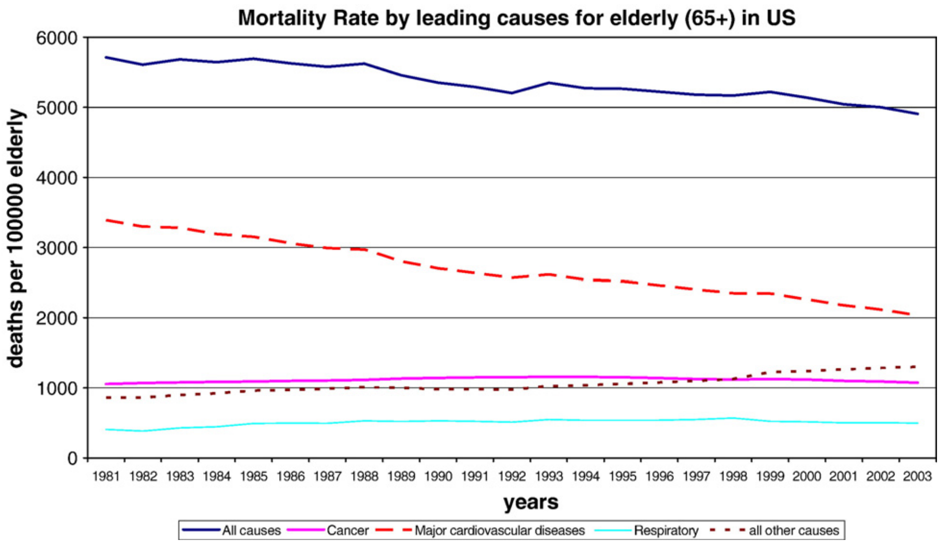

Fig. 3.

These evidences indicate that medical care plays a major role in reducing old age mortality — in particular from its main source, i.e., cardiovascular diseases. However, does medical care also contribute to reduce the absolute mortality differential between low and high-income individuals? The findings discussed in this section, albeit indirectly, suggest a positive role for medical care. Ceteris paribus, the increased income inequality in the US and the slower pattern of reduction in smoking by individuals in low socio-economic groups should have led to an increase in health inequality. Instead, the drop in the elderly mortality rate across all socio-economic groups was associated with a decline in the absolute mortality rate differential. This may suggest that medical care was more effective in reducing mortality – typically from cardiovascular diseases – among the low-income individuals.

Direct evidences of the role of medical care on the mortality differential are also available. Lichtenberg (2002) estimates a health production function, and finds that pharmaceutical innovations (new drugs) and public health expenditure are more effective in increasing longevity among blacks than among whites. Interestingly, his estimates suggest that – in absence of health expenditure growth and new drugs – black longevity would have actually decreased, thereby leading to an increase even in the absolute level of health inequality. In a study of health inequality among infants, Lin (2006) finds that access to medical care and changes in maternal behavior are the most important factors in reducing the health gradient, with the former accounting for 40% of the reduction. These findings are in line with the results in Cutler and Richardson (1998), who attribute most of the observed reduction in the health capital difference between rich and poor elderly to the increase in medical spending.

2.4. Public versus private health care

The literature reviewed in the previous section suggests that (public) medical care does play an important role in reducing old age mortality. Does private health care play a similar role? The answer to this question carries crucial policy implications, and is relevant for the assumptions underlying the theoretical model at Section 3. In fact, if mortality improvements are only due to greater access to health care – regardless of whether public or private – then public care simply amounts to a transfer of resources to the elderly that will crowd-out private health care, for those already covered by private insurance, and that will allow easier access to health care to those without private coverage. Public health care could then easily be substituted by a monetary transfer to the elderly, just like pension benefits, that allows the elderly to purchase private medical care.

However, several contributions in the health literature suggest that public and private health care are not perfect substitutes. Lichtenberg (2002) merges several datasets (National Hospital Discharge Survey, National Ambulatory Medical Care Survey, National Health Interview Survey and Social Security Administration life tables) to calculate the relative importance of the medical inputs in increasing longevity. His empirical analysis shows that both medical innovation (approvals of new drugs) and public expenditure on medical care contributed to the longevity increase during 1960–1997, but it suggests that private health expenditure has no impact on longevity.

Public health care programs induce also important dynamic responses that may lead to further increase in longevity. For instance, by reducing the marginal cost of receiving better health, programs such as Medicare may increase the demand of drugs and health treatments among the elderly. This effect will in turn create additional incentives to invest in the development of new drugs and medical treatments, hence leading to further improvements in mortality (see Manton et al., 1997).

Another hint that public and private are not perfect substitutes comes from Cutler and Gruber (1996), who analyze how different Medicaid provisions across US states affects the low-income individuals' health insurance decisions. They estimate the extent of the crowding out between Medicaid and private (typically employers' provided) health insurance to be only around 50%. This finding suggests that, even in the presence of public medical care, private health has a specific role to play. Besley et al. (1999) show that private health care may indeed provide better quality health care.[6] For instance, they show that long waiting lists for the UK National Health Service are perceived as reducing quality of service and tend to increase the purchase of private health insurance. They estimate that an increase of one person per thousand in the long term waiting list raises the probability of an average individual to buy private insurance by 2%.

[6] This may be due to the different incentives provided by public and private programs. Currie et al. (1995) suggest that state Medicaid programs pay low fees that could represent a deterrent to physician willingness to serve Medicaid patients or to provide them high quality care.

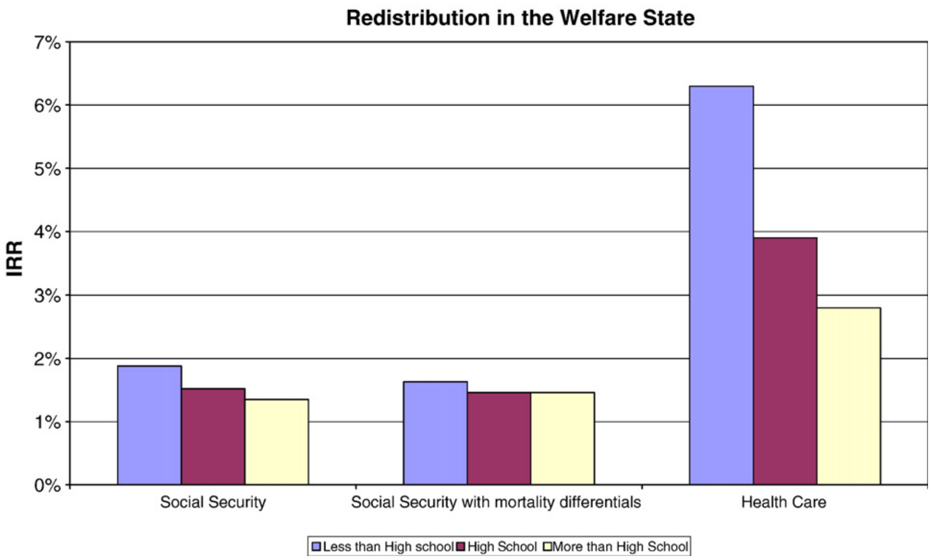

Fig. 4.

2.5. *Redistribution in public health care and social security*

We now turn to the design of health care and social security to assess their degree of intragenerational redistribution. PAYG pension systems are typically financed through a contribution paid by the workers, which is proportional to their labor income.[7] Pension benefits usually depend on worker's labor income, years of contributions, retirement age and even marital status, through calculation formulas that vary widely across countries — and often over time. To the extent that pension benefits are less than fully proportional to the workers' income (for instance because of the existence of a minimum pension), the system entails some redistribution, from high to low-income individuals. In an influential paper, Boskin et al. (1987) calculated the redistribution performed by the US social security system across income groups, family composition and gender. They showed that redistribution from high to low socio-economic status individuals is present, even after controlling for the differential mortality rates. Fig. 4 shows the internal rate of return (IRR) from social security by education groups calculated by Liebman (2002). When mortality differentials are taken into account, low-educated individuals still obtain higher returns, although the difference in IRR is clearly reduced.

Fig. 4 displays also the different returns from health care – namely, from part A of Medicare (hospital insurance benefits) – by education groups as calculated by Bhattacharya and Lakdawalla (2006). By combining contributions during the workers' lifetime and health care services received in old age, they show that – in spite of more educated individuals living longer – low-educated agents still enjoy higher returns from health care. In fact, not only is Medicare financed through a proportional contribution on labor income, so that high-income workers pay more, but low-income individuals receive a higher value of health care services. Furthermore, McClellan and Skinner (2006) suggest that public health care becomes even more redistributive, if also the value of the insurance coverage is considered. van Doorslaer et al. (1999) find similar evidence in a sample of OECD countries.

3. The economic model

We introduce an overlapping generation model with storage technology. Every period, two generations of non-altruistic agents are alive: young and old. Population grows at a constant rate $\eta > 0$. Individuals are endowed with a young age income, and retire in their old age. Every young agent survives until the second period; but longevity in the second period – i.e., the fraction of old age during which an agent is alive – may differ across individuals according to their income, and to the level of public health care.

[7] Floors and ceilings often apply to the labor income over which contributions are levied, or alternatively to the total contribution by a worker.

Agents are assumed to be heterogeneous in their young age income, e, which is distributed on the support $[\underline{e}, \overline{e}] \subset \Re_{+}$, according to the cumulative distribution function $G(.)$. An individual born at time t is characterized by an income level, and will therefore be denoted by $e_t \in [\underline{e}, \overline{e}]$. The distribution of abilities is assumed to have mean $\tilde{e}$, and to be skewed

$$\int_{\underline{e}}^{\overline{e}} edG(e) = \tilde{e}, G(\tilde{e}) > \frac{1}{2}.$$

To capture the health gradient and the non-linear effect of public health care on longevity discussed at Section 2, we postulate the following longevity function, $\delta(e,h_t)$, which identifies the fraction of the old age that a type-e individual born at time $t-1$ is alive for:

$$\delta_{e,t} = \delta(e, h_t) = \tilde{\delta}_t(h_t)\left[1 + E_t\left[\frac{\overline{H} - h_t}{\overline{H}}\right]\right] \tag{3.1}$$

$$\text{with } E_t = \frac{e_{t-1} - \tilde{e}_{t-1}}{\tilde{e}_{t-1}} \tag{3.2}$$

$$\text{and } h_t = \gamma H_t. \tag{3.3}$$

Individual longevity for a type-e elderly person depends on the effective public health care at time t, h_t, which combines a measure of health care productivity, $\gamma \in [0,1]$, and of public expenditure in health care, H_t, where $\overline{H}$ represents the upper bound on the public health expenditure. The effective public health care, h_t, has a positive impact on the average longevity in the society, that is, $\tilde{\delta}_t(h_t) \in (0, 1]$ and $\partial\tilde{\delta}_t/\partial h_t \geq 0$, but affects also the health gradient, which is represented by the expression in brackets in Eq. (3.1), where E_t is a measure of the distance of a type-e_{t-1} from the mean type-$\tilde{e}_{t-1}$. A restriction on the elasticity of the average longevity to the effective public health care is sufficient to guarantee that the longevity function captures the features described in the previous section. In particular, we assume that

$$\varepsilon_{\tilde{\delta},h} = \frac{\partial \tilde{\delta}}{\partial h}\frac{h}{\tilde{\delta}} \in \left[\frac{\overline{E}h}{\overline{H} + \overline{E}(\overline{H} - h)}, \frac{h}{\overline{H} - h}\right]. \tag{3.4}$$

To summarize, individuals' longevity depends positively on their income $\partial\delta_{e,t}/\partial E_t > 0$; and public health care increases the individual (the average) longevity, $\partial\delta_{e,t}/\partial h_t > 0 \ \forall e$, but reduces the longevity difference among individuals with different incomes, $\partial\Delta_\delta/\partial h_t < 0$, where $\Delta_\delta = \delta(e', h_t) - \delta(e, h_t) > 0$ with $e' > e$.

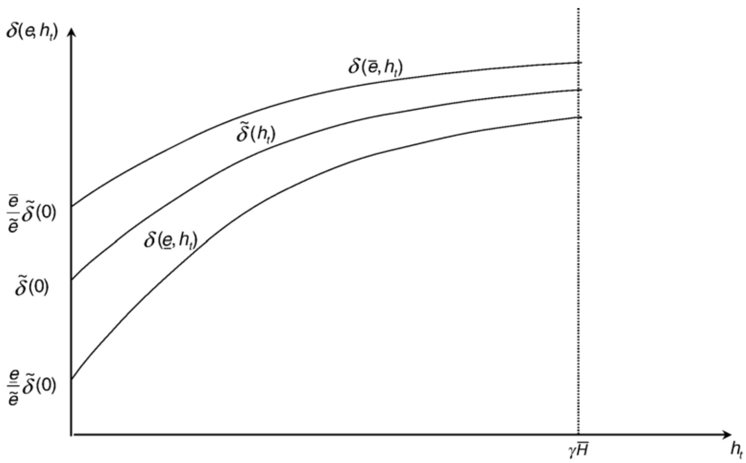

Fig. 5.

Fig. 5 shows the evolution of the individuals' longevity – and hence of the health gradient – for different level of public health care.

Agents are assumed to value consumption and health care in old age only,[8] according to a Cobb–Douglas utility function:

$$U(c^t_{t+1}, m^t_{t+1}) = (c^t_{t+1})^{\varepsilon}(m^t_{t+1})^{1-\varepsilon} \tag{3.5}$$

where c is consumption, and m is the health care. Subscripts indicate the calendar time and superscripts indicate the period when the agent was born.

As in Epple and Romano (1996), agents value public and private health care jointly, as a composite good, m. Health care may play a double role in our model, by providing medical services that improve the quality of life of the individuals – therefore increasing their utility[9] – and by affecting longevity. Public and private health care are not perfect substitutes. In our setting, while public health care plays both roles, private health care may only improve the living standard of the individuals. However, private health care is assumed to be more efficient than public health in providing the medical services that raise the quality of life of the agents. Thus, at time t, the health care services provided to an old agent, m_t, is equal to:

$$m_t = b_t + \alpha H_t \tag{3.6}$$

where b_t and H_t are respectively the expenditure in private and public health care received by an old person,[10] and $\alpha \in (0,1)$ measures the efficiency gap between private and public health care.[11]

A storage technology allows to transfer one unit of consumption today into $(1+R)$ units of consumption tomorrow. Additionally, we assume that $R > \eta$, and thus the economy is dynamically efficient. All private transfers of resources take place through this storage technology.

The budget constraint of a type-e agent born at time t is

$$c^t_{t+1} + b^t_{t+1} \leq (1+R)e_t(1-\tau_t) + \delta_{e,t+1}P_{t+1} \tag{3.7}$$

where τ_t is the tax rate at time t on the youth endowment. Young agents take no economic decision; they simply save their net income for future consumption. When old, individuals are entitled to a (one-time) public health care and receive a lump sum pension for the remaining duration of their life. They use their pension income and their saving to finance their private consumption and their expenditure in private health care.

At time $t+1$, an elderly person determines her demand for consumption and for private health care by maximizing her utility function, Eq. (3.5), with respect to c^t_{t+1} and b^t_{t+1}, subject to the budget constraint at Eq. (3.7). We call $W^t_{e,t+1}$ the net wealth of a type-e old agent at time $t+1$:

$$W^t_{e,t+1} = e_t(1-\tau_t)(1+R) + \delta_{e,t+1}P_{t+1} + \alpha H_{t+1}. \tag{3.8}$$

The optimal demands for consumption and private health care of a type-e old agent at time $t+1$ are respectively:

$$\begin{aligned} c^{*t}_{e,t+1} &= \varepsilon W^t_{e,t+1} \\ b^{*t}_{e,t+1} &= (1-\varepsilon)W^t_{e,t+1} - \alpha H_{t+1}. \end{aligned} \tag{3.9}$$

[8] This assumption greatly simplifies the analysis, but entails some costs. First, we do not model the demand for private (and public) young age health care, and simply assume that longevity depends on the income. Second, we abstract from saving decisions, which may be relevant for the political sustainability of social security, see Boldrin and Rustichini (2000), and Cooley and Soares (1998).

[9] Since Grossman (1972, 1999) seminal contributions, health care has been assumed to provide utility, either directly or by increasing the utility from consumption, as in Epple and Romano (1996) and Philipson and Becker (1998).

[10] Notice that by abstracting from introducing a measure of health care productivity in the individual consumption of public health care, we choose to concentrate on the impact of health care productivity improvements on longevity only. This issue will be addressed in section 6.

[11] Notice that for the agents whose income is below the mean, if $\alpha = 1$, public health dominates private health, since it provides the same level of utility, and additionally raises their longevity.

Hence, the demand for private health is increasing in the individual endowment,[12] and may – at most – be partially crowded-out by the public health care, since $\partial b^{*t}_{e,t+1}/\partial H_{t+1} = -\alpha\varepsilon > -1$.

3.1. The welfare state

Our welfare state consists of two instruments – public health care and social security – which transfer resources from workers to retirees. At time t, every young contributes a proportion, τ_t, of her endowment to the welfare state, and every retiree is entitled to health care benefits, H_t, and to a pension, P_t.

There exists a fundamental difference between pension transfers and public health care in this model. A pension transfer is a lump sum annuity to the elderly. Characterizing the pension as a lump-sum transfer simplifies the political analysis at following sections and is consistent with the pension system redistributing from high to low-income individuals (see Section 2.5). Yet, since the pension is a (lump-sum) annuity, and people with higher income live longer – thus receiving pension benefits for a longer period – this redistributive element is reduced.

Public health care instead entitles the elderly to a medical service. How can we measure the extent to which individuals with different health status and longevity use this service? High-income individuals enjoy better health conditions, but live longer, and may obtain access to more expensive medical treatments at very old age; whereas low-income individuals have lower longevity, but may require a more intensive use of pharmaceutical drugs and medical treatments while alive. To keep the analysis tractable, we choose to consider public health care as a lump sum expenditure, which occurs only once in old age. This characterization is consistent with the public health care system featuring an element of intragenerational redistribution (see Section 2.5).

In our setting, since young agents are endowed with a fixed endowment, an income tax creates no distortion. To introduce a distortionary effect of taxation, and thereby to avoid agents to have too extreme preferences over the welfare state, we assume a quadratic cost of taxation.[13]

The welfare state is assumed to be balanced every period, so that its total expenditure in both programs has to be equal to the amount of collected taxed, T_t. Let λ_t be the share of collected taxes dedicated to social security, and $(1-\lambda_t)$ to public health care. Accounting for the quadratic cost of taxation, the total amount of collected taxes is:

$$T_t = \tau_t(1-\tau_t)\int_{\underline{e}}^{\overline{e}} edG(e_t) = \tau_t(1-\tau_t)\tilde{e}_t. \tag{3.10}$$

Notice that as the tax rate, τ_t, increases so does its distortionary effect. In particular, the maximum of the Laffer curve is reached for $\tau_t=1/2$. Finally, the total amount of resources is divided between pensions:

$$\lambda_t T_t = \frac{\tilde{\delta}_t P_t}{(1+\eta)}, \tag{3.11}$$

where P_t is the lump sum pension transfer paid to every retiree during her old age period, and public health care:

$$(1-\lambda_t)T_t = \frac{H_t}{(1+\eta)}. \tag{3.12}$$

Finally, to simplify the algebra, we normalize the upper bound on the public health expenditure, $\overline{H}$, to the maximum amount of collectable taxes, i.e., $\tau=1/2$, entirely spent on health, i.e., $\lambda=0$, that is: $\overline{H}=(1+\eta)\tilde{e}_t/4$.

[12] It is convenient to assume that even the poorest individual has a non-negative demand for private health, i.e., that $(\underline{e}_t(1-\tau_t)(1+R)+\delta_{\underline{e},t+1}P_{t+1})/H_{t+1} \geq \alpha\varepsilon/(1-\varepsilon)$.

[13] We choose this approach, rather than the more natural one – to endogenize the labor supply – because it allows us to obtain a close form solution of the voting game.

3.2. The economic equilibrium

We can now define the economic equilibrium as follows:

Definition 3.1. For a given sequence of tax rates, pension shares, and real interest rates, $\{\tau_t, \lambda_t, R\}_{t=0}^{\infty}$, an economic equilibrium is a sequence of allocations, $\{c^t_{t+1}(e_t), b^t_{t+1}(e_t)\}_{e_t\in[\underline{e},\bar{e}]}^{t=0,\ldots,\infty}$, such that:

- in every period, agents maximize their utility function at Eq. (3.5), with respect to $c^t_{t+1}(e_t)$ and $b^t_{t+1}(e_t)$, subject to the budget constraint at Eq. (3.7);
- the welfare budget constraints are balanced every period, and thus Eqs. (3.10), (3.11) and (3.12) are satisfied; and
- the goods market clears every period:

$$\int_{\underline{e}}^{\bar{e}} b_t^{t-1}\mathrm{d}G(e_{t-1}) + \int_{\underline{e}}^{\bar{e}} c_t^{t-1}\mathrm{d}G(e_{t-1}) = (1-\tau_t)(1+R)\int_{\underline{e}}^{\bar{e}} e_{t-1}\mathrm{d}G(e_{t-1}) \\ +(1+\eta)\tau_t(1-\tau_t)\int_{\underline{e}}^{\bar{e}} e_{t-1}\mathrm{d}G(e_{t-1}) \qquad \forall t.$$

The utility level obtained by the agents in an economic equilibrium can be represented by their indirect utility functions. To this purpose, we can use the welfare state budget constraints and express the individual types, e, in terms of differences from the mean type-$\tilde{e}$, to obtain an indirect utility function for a type-E young that depends on current and future tax rates and on the future pension share:

$$v^t_{t,E}(\tau_t,\tau_{t+1},\lambda_{t+1},E_t) = \theta\tilde{e}(1+R)\{(1+E_t)(1-\tau_t) + [\lambda_{t+1}(1+E_t)+\alpha(1-\lambda_{t+1})]*(1+N)\tau_{t+1}(1-\tau_{t+1}) \\ -4E_t(1+N)\gamma\lambda_{t+1}(1-\lambda_{t+1})\tau^2_{t+1}(1-\tau_{t+1})^2\} \tag{3.13}$$

where $\theta=\varepsilon^{\varepsilon}(1-\varepsilon)^{(1-\varepsilon)}$ and $1+N=(1+\eta)/(1+R)$ represents the average relative performance of an intergenerational transfer scheme with respect to private savings. For a type-E old individual at time t the indirect utility function is:

$$v^{t-1}_{t,E}(\tau_{t-1},\tau_t,\lambda_t,E_t) = v^{t-1}_{t-1,E}(\tau_{t-1},\tau_t,\lambda_t,E_{t-1}) \quad \text{for } E_t = E_{t-1}. \tag{3.14}$$

4. The voting game

The size and the composition of the welfare state are decided by the agents through a political system of majoritarian voting. Elections take place every period, and all persons alive, young and old, cast a ballot over τ, the income tax, and λ, the share of pension in the welfare state. Individual preferences over the two issues are represented by the indirect utility functions at Eqs. (3.13) and (3.14), respectively for the young and the old. Notice that every agent has zero mass, and thus no individual vote could change the outcome of the election. We thus assume that individuals vote sincerely.

This majoritarian voting game has two important characteristics. First, the issue space is bidimensional, (τ, λ), and thus a Nash equilibrium may fail to exist, and second, the game is intrinsically dynamic, since it describes the interaction among successive generations of workers and retirees. To deal with these features, as Conde-Ruiz and Galasso (2003, 2005), we choose to combine the notion of structure induced equilibrium, due to Shepsle (1979), with the idea of subgame perfection. The use of this concept of subgame perfect structure induced equilibrium reduces the game to a dynamic issue-by-issue voting game.[14]

To characterize the equilibria of this voting game, we first analyze the case of full commitment, in which voters determine the constant sequence of the parameters of the welfare state (τ,λ). In absence of a state variable, this voting game is static, and thus the result in Shepsle (1979) [Theorem 3.1] can be applied to obtain the sufficient conditions for a (structure induced) equilibrium to exist. In particular, if preferences are single-peaked along every dimension of the issue space, a sufficient condition for (τ*, λ*) to be an equilibrium of the voting game with full commitment is that τ* represents the outcome of a majority voting over the jurisdiction τ, when the other dimension is fixed at its level λ*, and viceversa.[15]

[14] See Conde-Ruiz and Galasso (2003, 2005) for a detailed discussion.

[15] See Persson and Tabellini (2000) for a simple explanation of how to calculate a structure induced equilibrium.

Thus, to apply Shepsle (1979)'s theorem to our environment, we need to ensure that individuals' preferences are single peaked along the two dimensions, τ and λ. The following lemma describes a set of sufficient conditions.

Lemma 4.1. *Individuals' preferences are single-peaked over λ for given τ. If $E \geq \underline{E} = -(\lambda + \alpha\,(1-\lambda))/\lambda(1+4\gamma\,(1-\lambda))$ and $E \leq 1$, individuals' preferences are single-peaked over τ for given λ.*

We therefore restrict the support of ability type of young and old individuals, in order to have that $E = (e - \tilde{e})/\tilde{e} \in [\underline{E}, 1]$, that is $e \in [\tilde{e}(1+\underline{E}), 2\tilde{e}]$.

The second step to find a subgame perfect structure induced equilibrium is to show that the (structure induced) equilibrium outcomes of the game with commitment are also subgame perfect equilibrium outcomes of the voting game without commitment.[16] In the game with no commitment, voters may only pin down the current values of τ and λ, although, as it is typically the case in these social security games, they may expect their current voting behavior to affect future voters' decisions (for a survey of political economy models of social security, see Galasso and Profeta, 2002). We will return to this point at the end of the next section.

5. Politico-economic equilibria

In this section, individual votes over each dimension of the issue space, τ and λ, are examined issue-by-issue. Initially, we assume that current voters can determine future policies, i.e., there exists commitment. Voters cast a ballot over a constant sequence of τ, for a given constant sequence of λ, and viceversa. For each dimension, τ and λ, votes are then ordered to identify the median vote, which, by Shepsle (1979)'s theorem, represents the structure induced equilibrium outcome of the voting game with commitment. The results are then generalized to the game without commitment.

5.1. Voting over the size of the welfare state

Regardless of the composition of the welfare state, the elderly are net recipients from the system. Therefore, they will choose the tax rate that maximizes its size.

Lemma 5.1. *For any share of pension in the welfare state, λ, the most preferred tax rate by any type-E old individual, τ_E^O, is equal to 1/2.*

Today's young individuals may be willing to vote in favor of the welfare state, and thus to bear the cost of a current transfer, if their vote will also determine its future size, and thus their future benefits. In the game with commitment, a type-E young individual choose her vote, τ_E^Y, by maximizing her indirect utility function at Eq. (3.13) with respect to a constant sequence of tax rates, $\tau_t = \tau_{t+1} = \tau_E^Y$. The next lemma characterizes the vote of the young.

Lemma 5.2. *For a given share of pension, λ, the most preferred tax rate by any type-E young individual is positive, $\tau_E^Y > 0$, if $E < \hat{E}(\lambda)$, and it is equal to zero, $\tau_E^Y = 0$, if $E \geq \hat{E}(\lambda)$, where $\hat{E}(\lambda) = [\alpha(1+N)\,(1-\lambda)/(1-(1+N)\,\lambda)] - 1$. Moreover, τ_E^Y is weakly decreasing in E: $\frac{\partial \tau_E^Y}{\partial E} \leq 0$.*

Lemma 5.2 suggests that the political support to the welfare state relies heavily on its within-cohort redistribution component. While relatively high-income young individuals, $E \geq \hat{E}(\lambda)$, oppose the system, among the low-income young the preferred size of the welfare state is decreasing with the voter's types. Rich young individuals, $E > 0$, pay more taxes than the average, but receive the same public health expenditure and old age unitary pension as everybody else. Although they live longer, and thus enjoy a larger total pension transfer, this extra longevity is not sufficient to compensate for the higher contribution they make in youth. This effect becomes stronger as the public health share of the welfare expenditure increases, since public health reduces the longevity differential among types, and thus the total pension of the wealthy. Also intermediate young types, $\hat{E}(\lambda) \leq E < 0$, choose not to sustain the welfare state, despite receiving in old age more resources than they contribute in youth. In fact, this intergenerational welfare state constitutes an inefficient technology to transfer resources into the future, and their young age contributions exceed the present value of their benefits. Only low-income young types, $E \leq \hat{E}(\lambda)$, are net

[16] A full specification of the voting game without commitment is in the appendix.

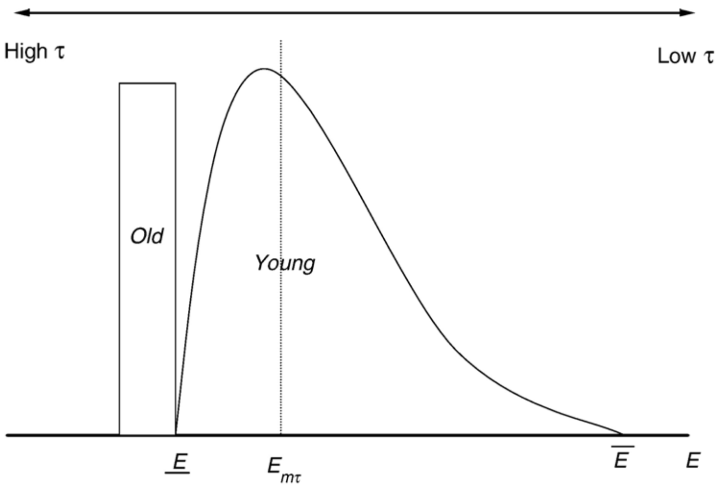

Fig. 6.

recipients,[17] and therefore vote for a positive welfare system, despite experiencing shorter longevity and thus enjoying smaller total pension transfers than richer agents.

The next lemma constitutes an important step towards our main result. It characterizes the relation between the size of the system chosen by a type $E<\hat{E}(\lambda)$ young individual and the pension share, λ, and discusses the complementarity between the two welfare systems.

Lemma 5.3. *The most preferred tax rate by any type-E young individual, with $E<\hat{E}(\lambda)$, is weakly increasing in λ for $\lambda\leq\lambda'$, and decreasing for $\lambda>\lambda'$, where $\lambda'=1/2-(1+E-\alpha)/16\gamma E\tau(1-\tau)<1/2$.*

For $\lambda=1$, the welfare state is a pure social security system. In this case, the longevity of the low-income individuals, and thus their total pension benefits, is too low to induce them to support the system. As part of the expenditure begins to be devoted to health care, $\lambda<1$, two effects take place. First, every agent experiences an improvement in the quality of her health. Second, the longevity differential decreases, and the total pension benefits of the low-income agents begin to raise until they are willing to support the welfare state. Indeed, as the share of health care increases, their most preferred size of the welfare state raises too. However, as the share of public health becomes very large – λ close to zero – the complementarity between the two programs drops: the longevity differential keeps decreasing, but not enough to compensate the reduction in the unitary pension, and hence the agents choose to downsize the welfare state.

It is now straightforward to order every agent's vote over the size of the welfare state, for a given pension share, and to identify the median voter's type. Agents can be ranked according to their age and type, as shown at Fig. 6, with elderly and then low-income young choosing larger sizes. The median voter is the type-$E_{m\tau}$ young agent who divides the electorate in halves: $G(E_{m\tau})=\eta/2(1+\eta)$. For a given pension share, λ, we identify her most preferred tax rate as $\tau_{E_{m\tau}}(\lambda)$.

5.2. Voting over the composition of the welfare state

When the issue at stake is the pension share, λ, for a given size of the system, τ, votes only differ according to the voters' type, while the voters' age plays no role. This is not surprising. In the game with commitment, today's decision will be in place tomorrow as well. And the composition of the welfare state is only relevant in old age, when the

[17] Notice that the mass of young voters in favor of the system, i.e., $E\leq\hat{E}(\lambda)$, depends on the relative share of the two welfare programs, λ. While a pure social security system, $\lambda=1$, would receive no support, as the share of health care increases so does the mass of voters in favor of the system. The reason is that the low-income young greatly enjoy public health, which redistributes resources in their favor, and decreases the longevity differential.

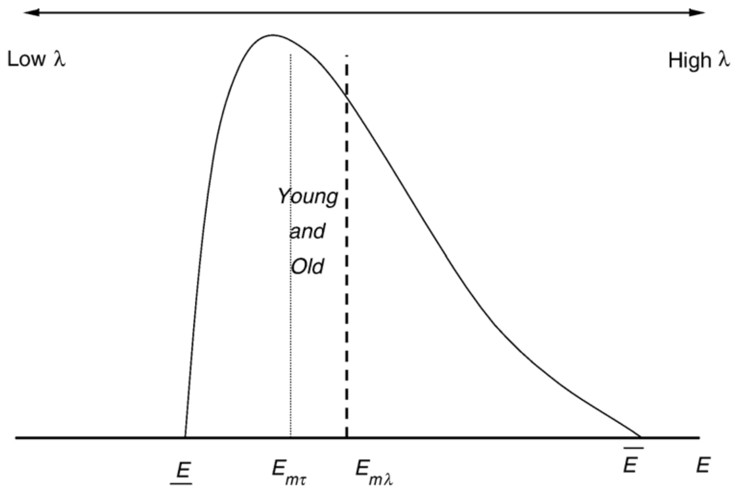

Fig. 7.

benefits from the two programs are received. Thus, a type-E young and a type-E old share the same voting decision: they determine their vote, λ_E , by maximizing their indirect utility function at Eqs. (3.13) and (3.14).

Lemma 5.4. *For a given tax rate, τ, the most preferred social security share, λ_E , by a type-E (young or old) individual is the following:*

(i) $\lambda_E = 1$, *if* $E > 0$;

(ii) $\lambda_E = \min\left\{1, \frac{1}{2} - \frac{1-\alpha+E}{8\gamma E\tau(1-\tau)}\right\}$ *if* $E \in [-(1-\alpha),\ 0]$;

(iii) $\lambda_E = \max\left\{0, \frac{1}{2} - \frac{1-\alpha+E}{8\gamma E\tau(1-\tau)}\right\}$ *if* $E < -(1-\alpha)$.

Moreover, λ_E is weakly increasing in E, i.e., $\frac{\partial \lambda_E}{\partial E} \geq 0$. And λ_E is weakly increasing in τ if $E \leq -(1-\alpha)$, and weakly decreasing in τ if $-(1-\alpha) > E > 0$.

Lemma 5.4 characterizes how the preferred composition of t?he welfare state depends on the individual type.

Rich agents, whose type is above the mean, $E > 0$, vote for a pure social security system, since public health reduces the longevity gap and increases the redistributive element of the system. Individuals with intermediate income (cases *ii* and *iii*) typically exploit the complementarity and hence favor a combination of the two programs, in order to increase their relative longevity and to receive an old age pension,[18] while the very poors (case *iii* with $\lambda_E = 0$) favor health care only.

The relation between the composition of the system chosen by a type-E individual, λ_E, and its size, τ, depends on the voter's type. The votes of the extremely high-income ($\lambda_E = 1$) and low-income ($\lambda_E = 0$) individuals are unaffected by changes in the size.

Among the intermediate income types, agents with relatively low-income will respond to a raise in the size of the system with an increase of the pension share, since a larger unitary pension will compensate lower longevity; whereas agents with higher income will trade-off a lower pension with more public health.

Following the previous lemma, we can order the votes on the composition of the system according to the voters' types, as shown in Fig. 7. The median voter is the low-income type-$E_{m\lambda}$, who divides the electorate in halves: $G(E_{m\lambda}) = 1/2$. For a given size of the system, τ, we identify her most preferred composition as $\lambda_{E_{m\lambda}}(\tau)$.

Figs. 7 and 8 show a different ordering of votes along the two dimensions of the policy space. In fact, in deciding the size of the system, the age of the voters plays an important role, since the elderly favor the largest system, whereas only individual types matter in the composition. As a result, the median voter over the λ-direction has a higher type than the median voter over the τ-dimension: $E_{m\lambda} > E_{m\tau}$.

[18] It is interesting to notice that for very small dimensions of the welfare state, $\tau \simeq 0$, preferences over its composition are extremely polarized, $\lambda_E = 0$ if $E \leq -(1-\alpha)$ and $\lambda_E = 1$ if $E > -(1-\alpha)$, since the welfare state does not have enough resources for the complementarity to kick in.

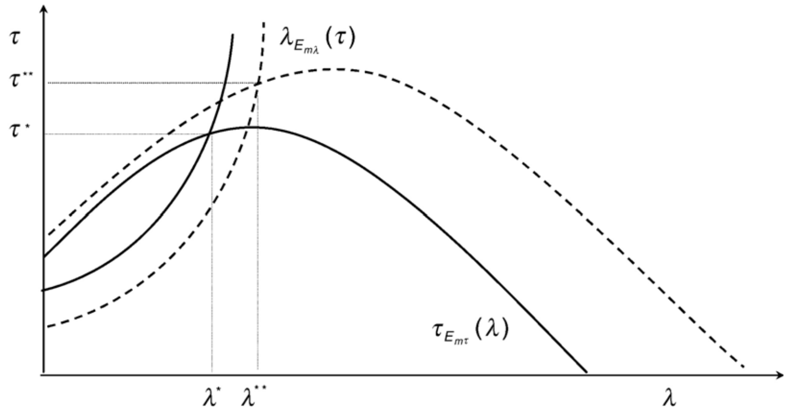

Fig. 8.

5.3. Characterization of equilibria

In the previous sections, we have analyzed the voting behavior of all individuals along the two dimensions of the issue space, i.e., size and composition of the welfare state, under the assumption of commitment. Since preferences are single peaked, we can now apply Shepsle (1979)'s result, and characterize the structure induced equilibria of the game with commitment.

Proposition 5.5. *There exists a structure induced equilibrium, (τ^*, λ^*), of the voting game with commitment, such that:*

(A) $(\tau^*=0, \lambda^*=1)$ *if* $E_{m\lambda} \geq -(1-\alpha)$ *and* $\forall E_{m\tau}$;
(B) $(\tau^*=0, \lambda^*=0)$ *if* $E_{m\lambda} < -(1-\alpha)$ *and* $E_{m\tau} \geq \hat{E}(\lambda)$;
(C) $(\tau^*>0, \lambda^*=0)$ *if* $E_{m\lambda} < -(1-\alpha)$, *and* $\Omega(E_{m\lambda}) \leq E_{m\tau} < \hat{E}(\lambda)$;
(D) $\left(\tau^*>0, 0<\lambda^*<\frac{1}{2}\right)$ *if* $E_{m\lambda} < -(1-\alpha)$, $E_{m\tau} < \min\{\hat{E}(\lambda), \Omega(E_{m\lambda})\}$ *where* $\Omega(E_{m\lambda}) = -1 + \alpha(1+N)\sqrt{-\frac{1}{\gamma}\left(\frac{1-\alpha}{E_{m\lambda}} + 1 - \gamma\right)}$.

No welfare state will exist also if the median voter over λ is sufficiently rich (case A), and hence prefers pensions only, $\lambda^*=1$, since in this case no young individual will be willing to support the system. If, on the other hand, a poorer median voter over λ prefers more health care, the size of the system will depend on the type of the median voter over τ, $E_{m\tau}$. If the median voter over τ is sufficiently rich (case *B*), no welfare state will exist, $\tau^*=0$. The poorer the median voter, the larger the system will be. Case *D* represents the most interesting situation, in which a sufficiently poor median voter will exploit the complementarity between health care and social security, and hence choose a system composed of both programs.[19]

What happens if we relax the assumption of commitment and consider a game in which voters may only determine the current size and composition of the welfare system? The results in Proposition 5.5 generalize to a game without commitment:

Proposition 5.6. *Every pair (τ^*, λ^*), which constitutes a (structure induced) equilibrium of the voting game with commitment, is a (subgame perfect structure induced) equilibrium of the game without commitment.*

Proposition 5.6 suggests that there exists a system of punishment and rewards, which makes the equilibrium outcome of the game with commitment a subgame perfect equilibrium outcome of the game without commitment. The intuition is straightforward. Old agents' voting behavior does not depend on tomorrow's policy and thus on the existence of commitment. Low-income young individual, who were in favor of the welfare state in the case of commitment, will now be willing to enter an "implicit contract" among successive generations of voters to sustain the welfare state. This "implicit contract" specifies that if current young support the existing welfare system, they will be rewarded with a corresponding transfer of resources (pension and health care) in their old age, or they will be punished and receive no transfers.

[19] Proposition 5.5 does not provide a complete characterization of the structure induced equilibria of the game, since multiple (interior) equilibria may arise in cases A and C, if the reaction function $\tau^*(\lambda)=\tau_{E_{m\tau}}(\lambda)$, representing the decision of the median voter over τ, becomes sufficiently steep, and crosses the reaction function of the median voter over λ, $\lambda^*(\tau)=\lambda_{E_{m\lambda}}(\tau)$, for some $(\tau^*>0, \lambda^*>0)$.

6. Technological progress in health care

This section analyzes the impact of an improvement in the health care technology on the political decisions over the size and the composition of the welfare state. Technological progress is identified by an increase in the parameter γ of the longevity function (see Eqs. (3.1)–(3.3)), which determines the effectiveness of public health care in raising life expectancy.

We concentrate on an economy featuring a welfare state with both health care and pensions (case *D* in Proposition 5.5). As public health spending becomes more efficient in increasing longevity – and in reducing the longevity differential – the returns from the pension system for low-income workers increase. The (low-income) median voter over the composition of the system (a type-$E_{m\lambda}<-(1-\alpha)$) will find pension spending more convenient and will thus increase the pension share in the welfare state composition. For moderate changes of this composition – i.e., if the pension share does not increase dramatically – the (low-income) median voter over the size of the system ($E_{m\tau}<\min\{\hat{E}(\lambda), \Omega(E_{m\lambda})\}$) will find the welfare system more appealing and will increase its size. Technological progress in health care will hence lead to more welfare spending. The next proposition qualifies this finding, while Fig. 8 provides a graphical interpretation.

Proposition 6.1. *Consider the equilibrium (τ*, λ*) at case (D) in Proposition 5.5. For a sufficiently poor median voter over λ, that is, if $E_{m\lambda}\leq\frac{2(1-\alpha)E_{m\tau}}{1-\alpha-E_{m\tau}}$, an increase in the health care productivity parameter, γ, leads to an equilibrium (τ**, λ**), with a larger welfare state, $\tau^{**}>\tau^{*}$, and a larger share of pensions, $\lambda^{**}>\lambda^{*}$.*

The sufficient condition in the above proposition guarantees that the median voter over λ has a sufficiently low-income – thereby being favorable enough to health care – to be induced by the technological progress to increase the share of pension, yet not to push the composition of the welfare state so far towards pensions as to induce the median voter over τ to downsize the system. Under this condition, the complementarity between the programs is preserved – indeed increased – and technological progress in health care leads to more welfare spending.

An improvement in the health care technology that increases the average longevity has also important effects on the demographic structure of the economy. In our model, every young individual survives until the beginning of the old age (the second period), and longevity refers to the percentage of the second period during which an individual is alive. If all individuals were to live until the end of the second period, $\delta_e=1\ \forall e$, the ratio of elderly to young would be equal to $\frac{1}{1+\eta}$, as in a standard 2-period overlapping generations model. However, individual longevity, which depends on the ability type, will typically be lower, $\delta_e\leq 1$. Since the average longevity is $\tilde{\delta}_t(h_t)$, the demographic structure is characterized by an average ratio of elderly to young equal to $\frac{\tilde{\delta}_t(h_t)}{1+\eta}$. Hence, an improvement in the health care technology will lead to an increase of this ratio, and thus to population aging.

To summarize, an improvement in the health care technology leads to more welfare spending, but also to more aging. Will the per-capita (or per-elderly) welfare spending also increase? The answer depends crucially on the functional form of $\tilde{\delta}_t(h_t)$, which determines the relative magnitude of these effects. To further address this issue, we thus turn to a numerical example.

6.1. A numerical example

To analyze the effect of an improvement in the health care efficiency on the per-elderly welfare spending we apply our model to the US economy. At the beginning of the 80s, which we take to be the starting point of our analysis, the percentage of US public health care expenditure over GDP was 4.35% (see the Office of the Actuary, National Health Statistics atwww.cms.hhs.gov/NationalHeqalthExpendData), while public pension expenditure (OASI) was 4.05% of GDP (see Social Security Administration data atwww.ssa.gov/OACT/TRSUM/trsummary). We thus take the total contribution rate, τ, to be 8.4%, which represents the total health care and public pension spending over GDP, while the relative share of health care over total welfare spending, λ, is calculated to be around 48%. According to these data, the US hence featured an equilibrium welfare state as described at case *D* in Proposition 5.5. The model has thus to deliver these values, $\tau=8.4\%$ and $\lambda=48\%$, as an equilibrium outcome, which allows to pin down two parameters related to the health care system, respectively the health care productivity, γ, and the quality efficiency gap between private and public health, α. They are $\gamma=0.86$ and $\alpha=0.79$.

Table 1
Changes in health care efficiency, welfare spending and longevity

	Change in γ (%)		
Changes (%) in	1	5	10
Contribution to welfare state (τ)	0.36	1.84	3.77
Composition of the welfare state (λ)	0.04	0.18	0.37
Total welfare spending (T)	0.33	1.67	3.41
Pension Spending (λT)	0.37	1.85	3.80
Health Care Spending ($(1-\lambda)T$)	0.29	1.50	3.06

Each period in our two-period overlapping generation model is assumed to last 40 years: from 25 to 64 and from 65 – the normal retirement age in the US in 1980 – until the age of 105. Every individual is assumed to survive at least until age 65, while individual longevity determines the share of the second period (from 65 to 105) during which an agent is alive. Since the average life expectancy at the age of 65 was 17 years (see the OECD Health Database at www.oecd.org/health/healthdata), the average individual longevity, $\tilde{\delta}_t(h_t)$, has to be 0.425.

To further specify the model, we use the following longevity function:

$$\delta(e, h_t) = \left(0.4 + 0.07\sqrt{\frac{h_t}{\overline{H}}}\right)\left(1 + E_t\left(1 - \frac{h_t}{\overline{H}}\right)\right)$$

where $h_t/\overline{H} = 4\gamma(1-\lambda)\tau(1-\tau)$. This function delivers an average individual longevity equal to 0.425, and displays all the properties discussed at Section 3 (see a graphical representation at Fig. 5).

To match the demographic and economic variables in the model to actual US data in the 80s, we set the annual population growth rate, which represents the other relevant demographic variable, to 1.7%, while the annual real interest rate is 4%. The combination of these two growth rates provides a measure of the relative profitability of the social security system to the average young, $1+N=(1+\eta)/(1+R)$, which suggests that over a 40-year period the returns from social security are less than half of those from private assets. However, since individuals differ in their ability – and thereby in the total contributions to the welfare state and in their longevity – their preferences on the size and composition of the welfare state will also differ. This difference is crucial also in determining the median voters over the two issues. The median voter over the composition of the welfare state, λ, corresponds to the individual with median income (see Section 5.2). Using US Census data (available atwww.census.gov/hhes/www/income/histinc), we match the average and median ability in the model with the 1985 mean and median household income (in 1980 dollars). The mean income ($\tilde{e}$) is equal to \$22,500 and the e median income is \$17,700. Hence, the relevant measure of the median voter over λ is: $E_{m\lambda}=-0.21$. We choose not to impose any functional form on the income distribution $G(.)$, but we need to identity the median voter over the size of the welfare state, τ . Since we know that her income is lower than the median income (see Section 5.1), we use as our benchmark[20] an income level of \$14,000, which yields $E_{m\tau}=-0.38$.

This set of parameter values allows us to reproduce the US welfare state of the beginning of the eighties as a type D equilibrium of the model. We can now analyze the effect of an increase of γ on the welfare system (τ and λ) and on the demographic structure. We consider three possible scenarios, with γ increasing by 1%, 5%, and 10%. Table 1 reports each corresponding political equilibrium.

Any improvement in health care efficiency leads to an increase in the overall size of the welfare state and in both health care ($(1-\lambda)T$) and pension spending (λT), but induces also further aging, as our demographic measure, the average ratio of elderly to young individuals, $\frac{\tilde{\delta}_t(h_t)}{1+\eta}$, increases. Does the per-capita (or per-elderly) welfare spending also increase? Our numerical example based on the US economy suggests a positive answer, since the percentage increase in the total welfare spending is always larger than the average increase in longevity. Technological progress in health care may hence be responsible of an increase in welfare spending also in per-capita terms.

[20] The qualitative results are not sensitive to reasonable changes in this median voter's income.

7. Concluding remarks

In most OECD countries, the welfare state makes contemporaneous use of two programs – public health and social security – to generate a flow of resources from workers to retirees. Both social expenditures have been increasing in the last few decades. Demographic dynamics are certainly responsible, since the number of recipients from these programs – the elderly – has largely increased, but often so have also the per capita resources.

This paper provides a new explanation for the contemporaneous existence – and increase – of health care and social security spending based on a political complementarity between these two programs. Political complementarity implies that the existence of health care increases the political support in favor of social security, and viceversa. Philipson and Becker (1998) emphasize the link from social security to public health. The existence of an annuity – the old age pension – increases the value of longevity and, hence, the demand for public health.

We focus on the opposite direction, from public health care to social security. We consider a model in which public health reduces the longevity differential between high and low-income agents, thereby increasing the value of the pension annuity to low-income individuals. This effect strengthens the within cohort redistributive component of social security, and increases the political support to this program among the low-income individuals. In a two-dimensional voting model, in which voters determine the size and the composition of the welfare state, we show that this political complementarity may lead to the adoption of a large welfare system, composed of both programs, in which the public health component is large, relatively to social security.

Our theoretical model carries an interesting testable implication. As health care becomes more effective in raising longevity and in reducing the longevity differential – due to more public spending and/or to technological improvements – the return from social security for low-income agents should increase, relatively to those for high-income individuals. Fig. 9 provides supporting evidence in this direction by reporting the differences in the internal rate of return (IRR) from social security for subsequent generations of US retirees according to socio-economic status – namely income – as provided by Gokhale and Kotlikoff (2002). Using a dynamic microsimulation model, Gokhale and Kotlikoff (2002) estimate the social security's treatment for several cohorts of US individuals, from those born in 1945–49 till those born in 1995–2000. Computing IRR requires data on social security contributions and benefits. While contributions' histories for the early cohorts may be available, data on future contributions and benefits need to be forecasted. Fig. 9 summarizes the difference in internal rate of returns between individuals in the lowest and the highest income quintile for three cohorts, 1945–49, 1970–74 and 1995–2000, under different scenarios. "Current rules" refers to a scenario with current contribution rates and pension benefits. In this case, the IRR differential is expected to increase slightly, from 4.9% to 5.1%. Yet, due to population aging, the current level of contribution rate

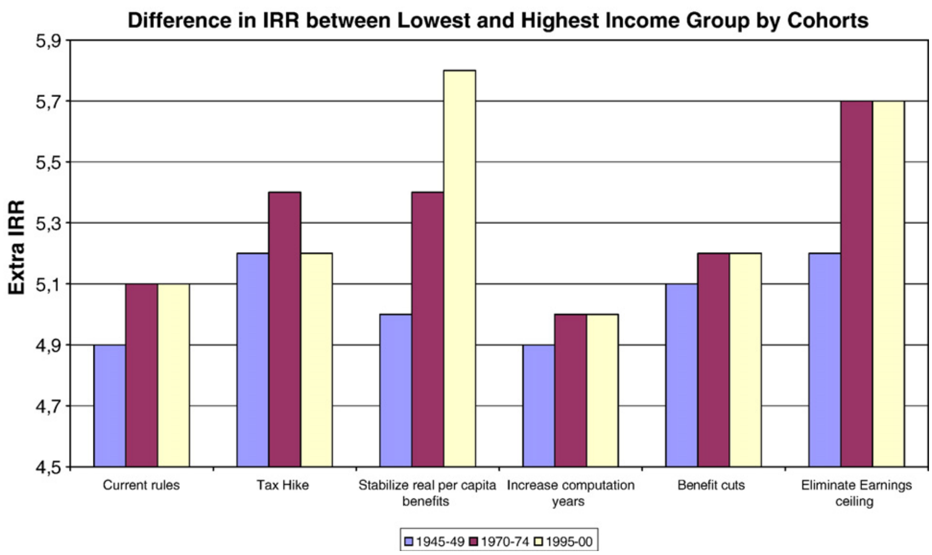

Fig. 9.

may not be sufficient to finance future pension benefits at the current generosity level. The remaining sets of columns in Fig. 9 presents the IRR differentials under five alternative reform scenarios. With the exception of the reform featuring a tax rate increase (around the year 2000), in which case the IRR differential increases only temporarily (i.e., for the 1970–74 cohort), in all other reform scenarios the difference in IRR between low and high-income individuals is forecasted to increase. The magnitude of this change depends on reform option considered.

These estimates hence provide supporting evidence to the relevance of this notion of political complementarity between health care and social security in the debate on the contemporaneous raise in health care and social security spending. Further research in this area should follow to help evaluating quantitatively how much of the increase in social security could plausibly be explained by lower mortality differentials, and to incorporate this political element in the forecast of future spending.

Appendix A

Proof of Lemma 4.1. Consider first the dimension λ for a given τ. For a type-E agent, the second derivative w.r.t. λ of her indirect utility function, Eq. (3.13), is $8\theta\tilde{e}\ (1+R)(1+N)\gamma E\tau^2\ (1-\tau)^2$. Since $\theta\tilde{e}(1+R)(1+N)\gamma>0$, her indirect utility function is quasi concave and preferences are clearly single peaked if $E\leq 0$. For $E>0$, the indirect utility function is convex. However, since the first derivative w.r.t. λ evaluated in $\lambda=0$ is positive, these agents simply prefer higher λ to lower λ, and preferences are still single peaked, with a maximum in $\lambda=1$.

Consider now the dimension τ for a given λ. For a type-E old agent, the second derivative w.r.t. τ of her indirect utility function, Eq. (3.14), is

$$\mathrm{SOC}_E^O(\tau) = 2\theta\tilde{e}(1+R)(1+N)\{-\lambda(1+E) - \alpha(1-\lambda) - 4E\lambda(1-\lambda)\gamma(1-6\tau+6\tau^2)\}.$$

Notice that $1-6\tau+6\tau^2\geq 0$ for $\tau\leq\tau_1=\frac{1}{2}-\frac{1}{6}\sqrt{3}$ and $\tau\geq\tau_2=\frac{1}{2}+\frac{1}{6}\sqrt{3}$. Thus, it is easy to see that for $E\geq 0$ and $\tau\leq\tau_1$ or $\tau\geq\tau_2$, and for $E\leq 0$ and $\tau_1\leq\tau\leq\tau_2$, then $\mathrm{SOC}_E^O(\tau)\leq 0$. For $E>0$ and $\tau_1\leq\tau\leq\tau_2$, the last term in the $\mathrm{SOC}_E^O(\tau)$ is positive. This term reaches its maximum for $\tau=1/2$, thus if $\mathrm{SOC}_E^O(\tau=1/2)<0\rightarrow\mathrm{SOC}_E^O(\tau)<0\ \forall\tau$. It is straightforward to see that $\mathrm{SOC}_E^O(\tau=1/2)<0$ if $E\leq\frac{\lambda+\alpha(1-\lambda)}{\lambda(2\gamma(1-\lambda)-1)}>1$. Finally, the last term in the $\mathrm{SOC}_E^O(\tau)$ is also positive for $E<0$ and $\tau\leq\tau_1$ or $\tau\geq\tau_2$, and is largest for $\tau=0$ or $\tau=1$. Thus if $\mathrm{SOC}_E^O(\tau=0)<0\rightarrow\mathrm{SOC}_E^O(\tau)<0\ \forall\tau$. It is easy to see that $\mathrm{SOC}_E^O(\tau=0)<0$ if $E>\underline{E}=-\frac{\lambda+\alpha(1-\lambda)}{\lambda(1+4\gamma(1-\lambda))}$.

For a type-E young agent, the second derivative w.r.t. λ of her indirect utility function is the same as for a type-E old agent, except for a multiplicative constant, $1+N$, and thus the same restrictions apply, which proves the lemma. □

A.1. Voting game without commitment

We consider that voters may only determine current size and composition of the welfare state, although they may expect their vote to condition future voters' decisions. The voting game with no commitment is defined as follows.

The sequence of tax rates and pension shares until $t-1$ constitutes the public history of the game at time t, $h_t=\{(\tau_0,\lambda_0),\ldots,(\tau_{t-1},\lambda_{t-1})\}\in X_t$, where X_t is the set of all possible history at time t.

An action for a type-E young individual at time t is a pair of tax rates and pension shares, $a_{t,E}^Y=(\tau,\lambda)\in\Upsilon$, where $\Upsilon=\{(\tau,\lambda)\colon \tau\in[0,1],\lambda\in[0,1]\}$. Analogously, an action for a type-E old individual at time t is $a_{t,E}^O=(\tau,\lambda)\in\Upsilon$. We call a_t the action profile of all individuals (young and old) at time t: $a_t=(a_t^Y\cup a_t^O)$ where $a_t^Y=\bigcup_{E\in[\underline{E},1]} a_{t,E}^Y$ and $a_t^O=\bigcup_{E\in[\underline{E},1]} a_{t,E}^O$.

For a type-E young individual a strategy at time t is a mapping from the history of the game into the action space: $s_{t,E}^Y$: $h_t\rightarrow\Upsilon$, and analogously for a type-E old individual at time t: $s_{t,E}^O$: $h_t\rightarrow\Upsilon$. The strategy profile played by all individuals at time t is denoted by $s_t=(s_t^Y\cup s_t^O)$ where $s_t^Y=\bigcup_{E\in[\underline{E},1]} s_{t,E}^Y$ and $s_t^O=\bigcup_{E\in[\underline{E},1]} s_{t,E}^O$.

At time t, for a given action profile, a_t, the pair (τ_t^m,λ_t^m) represents the medians of the distributions of tax rates. We take (τ_t^m,λ_t^m) to be the outcome function of the voting game at time t. This outcome function corresponds to the structure induced equilibrium outcome of the voting game with commitment, according to Shepsle's (1979) results. The history of the game is updated according to the outcome function; at time $t+1$: $h_{t+1}=\{(\tau_0,\lambda_0),\ldots,(\tau_{t-1},\lambda_{t-1}),(\tau_t^m,\lambda_t^m)\}\in X_{t+1}$.

For every agent, the payoff function corresponds to her indirect utility. Formally, for a given sequence of action profiles, $(a_0,\ldots, a_t, a_{t+1},\ldots)$, and of corresponding realizations, $((\tau_0, \lambda_0),\ldots, (\tau_t, \lambda_t), (\tau_{t+1}, \lambda_{t+1}), \ldots)$, the payoff function for a type-E young individual at time t is $v^t_{t,E}(\tau_t, \tau_{t+1}, \lambda_{t+1}, E_t)$, as defined in Eq. (3.13), and for a type-E old agent is $v^{t-1}_{t,E}(\tau_{t-1}, \tau_t, \lambda_t, E_t)$, according to Eq. (3.14).

Let $s^Y_{t|E'}=s^Y_t/s^Y_{t,E'}$ be the strategy profile at time t for all young individuals except for type-E', and let $s^O_{t|E'}=s^O_t/s^O_{t,E'}$ be the strategy profile at time t for all old individuals except for the type-E'. Then, at time t, a type-E' young individual maximizes

$$V^t_{t,E'}(s_o,\ldots,(s^Y_{t|E'},s^Y_{t,E'}),s^O_t,s_{t+1},\ldots)=v^t_{t,E}(\tau^m_t,\tau^m_{t+1},\lambda^m_{t+1},E'_t)$$

and a type-E' old individual maximizes

$$V^{t-1}_{t,E'}(s_o,\ldots,(s^O_{t|E'},s^O_{t,E'}),s^Y_t,s_{t+1},\ldots)=v^{t-1}_{t,E}(\tau^m_t,\lambda^m_t,E'_t)$$

where, according to our previous definition of the outcome function, (τ^m_t, λ^m_t) and $(\tau^m_{t+1}, \lambda^m_{t+1})$ are, respectively, the medians among the actions over the size and composition of the welfare state played at time t and $t+1$.

As previously argued, to deal with the two-dimensionality of the issue space, and to allow for intergenerational implicit contracts to arise, our equilibrium concept combines subgame perfection with the notion of structure induced equilibrium. We can now define a subgame perfect structure induced equilibrium of the voting game as follows:

Definition 1 (SPSIE). A voting strategy profile $s=\{(s^Y_t\cup s^O_t)\}^\infty_{t=0}$ is a Subgame Perfect Structure Induced Equilibrium (SPSIE) if the following conditions are satisfied:

- s is a subgame perfect equilibrium,
- at every time t, the equilibrium outcome associated with s is a Structure Induced Equilibrium of the static game with commitment.

Proof of Lemma 5.1. Trivial. For $E\in[\underline{E}, 1]$, the indirect utility function at Eq. (3.14) is concave w.r.t. τ , and is maximized at $\tau=1/2$. □

Proof of Lemma 5.2. Notice that the first order condition w.r.t. τ in the optimization problem of a type-E young voter is equal to the first order condition of a type-E old voter decreased by $1+E$, i.e., $\mathrm{FOC}^Y_E(\tau)=\mathrm{FOC}^O_E(\tau)-\theta\tilde{e}(1+R)(1+E)$. By Lemma 4.1, since $E\in[\underline{E}, 1]$, the indirect utility function is concave over τ , and thus a sufficient condition for a type-E young voter to maximize her indirect utility function in an interior, i.e., for $\tau>0$, is that the first order condition, evaluated at $\tau=0$, is strictly positive, $\mathrm{FOC}^Y_E(\tau=0)>0$. It is easy to see that if $E<\hat{E}(\lambda)=\dfrac{\alpha(1+N)(1-\lambda)}{1-(1+N)\lambda}-1$, then $\mathrm{FOC}_{\underline{E}}$ *$(\tau=0)>0$.*

Finally, to prove that $\frac{\partial\tau^Y_E}{\partial E}\leq 0$, notice that for $E>\hat{E}(\lambda)$ then $\tau^Y_E=0$, and $\frac{\partial\tau^Y_E}{\partial E}=0$. To examine the other case, $E\leq\hat{E}(\lambda)$, we differentiate the $\mathrm{FOC}^Y_E(\tau)$ w.r.t. τ^Y_E and E, and evaluate it at $\tau=\tau^Y_E$. We obtain that $\frac{\partial\tau^Y_E}{\partial E}=-\left.\frac{\frac{\partial\mathrm{FOC}^Y_E}{\partial E}}{\mathrm{SOC}^Y_E}\right|_{\tau^Y_E}<0$, since $\mathrm{SOC}^Y_E(\tau^Y_E)<0$, and it is easy to see that $\left.\frac{\partial\mathrm{FOC}^Y_E}{\partial E}\right|_{\tau^y_E}<0$. □

Proof of Lemma 5.3. For $E<\hat{E}(\lambda)$, by total differentiating the $\mathrm{FOC}^Y_E(\tau)$ at $\tau=\tau^Y_E$, we have that $\frac{\partial\tau^Y_E}{\partial\lambda}=-\left.\frac{\frac{\partial\mathrm{FOC}^Y_E}{\partial\lambda}}{\mathrm{SOC}^Y_E}\right|_{\tau^Y_E}<0$. Since $\mathrm{SOC}^Y_E(\tau^Y_E)<0$, then sign $\left(\frac{\partial\tau^Y_E}{\partial\lambda}\right)=\mathrm{sign}\left(\left.\frac{\partial\mathrm{FOC}^Y_E}{\partial\lambda}\right|_{\tau^Y_E}\right)$, where $\left.\frac{\partial\mathrm{FOC}^Y_E}{\partial\lambda}\right|_{\tau^Y_E}=\theta\tilde{e}(1+R)(1+N)(1-2\tau^y_E)[(1+E-\alpha)-8E\gamma(1-2\lambda)\tau^y_E(1-\tau^y_E)]=0$ for $\lambda'=\dfrac{1}{2}-\dfrac{(1+E-\alpha)}{16\gamma E\tau^y_E(1-\tau^y_E)}$. Thus, $\frac{\partial\tau^Y_E}{\partial\lambda}>0$ if $\lambda<\lambda'$, and $\frac{\partial\tau^Y_E}{\partial\lambda}\leq 0$ if $\lambda\geq\lambda'$. Notice that $E<\hat{E}(\lambda)$ implies that $E<-(1-\alpha)$, and thus $\lambda'<1/2$. □

Proof of Lemma 5.4. Case *i* follows from Lemma 4.1: recall that for $E>0$, $FOC_E(\lambda=0)>0$ and $SOC_E(\lambda)>0$. Notice that, for $E\in\left(-\frac{1-\alpha}{1-4\gamma\tau(1-\tau)},0\right)$ then $\mathrm{FOC}_E(\lambda=0)>0$, $\mathrm{SOC}_E(\lambda)<0$, and $\mathrm{FOC}_E(\lambda_E)=0$ for $\lambda_E=\dfrac{1}{2}-\dfrac{1-\alpha+E}{8\gamma E\tau(1-\tau)}$. However, for $E\in(-(1-\alpha), 0)$, case *ii*, λ_E could be greater than one, and thus we need to impose that $\lambda_E=\min\left\{\frac{1}{2}-\frac{1-\alpha+E}{8\gamma E\tau(1-\tau)},1\right\}$. For $E\in\left(-\frac{1-\alpha}{1-4\gamma\tau(1-\tau)},-(1-\alpha)\right)$, λ_E could be lower than zero, and thus we need to impose that $\lambda_E=\max\left\{0,\frac{1}{2}-\frac{1-\alpha+E}{8\gamma E\tau(1-\tau)}\right\}$. Finally, for $E\leq-\dfrac{1-\alpha}{1-4\gamma\tau(1-\tau)}$, $\mathrm{FOC}_E(\lambda=0)\leq 0$ and $\mathrm{SOC}_E(\lambda)<0$, thus $\lambda_E=0$, which proves case *iii*.

Moreover, it is straightforward to see that $\frac{\partial \lambda_E}{\partial E}>0$ for $\lambda_E \in (0,\ 1)$ and $\frac{\partial \lambda_E}{\partial E}=0$ for $\lambda_E=\{0,\ 1\}$. Finally, $\frac{\partial \lambda_E}{\partial \tau}=\frac{(1-\alpha+E)(1-2\tau)}{8\gamma E\tau^2(1-\tau)^2}$, which is non-negative for $E \leq -(1-\alpha)$, and negative for $0>E>-(1-\alpha)$. □

Proof of Proposition 5.5. By Shepsle (1979)'s Theorem 3.1, a structured induced equilibrium is a pair (τ^*, λ^*), in which τ^* is the median vote over the dimension τ , when the other dimension is fixed at the level λ^*, and λ^* is the median vote over the dimension λ, when the other dimension is fixed at the level τ^*. We have previously identified the median voters, respectively over the dimension τ and λ, with a type-$E_{m\tau}$ young and a type-$E_{m\lambda}$ (young or old) individual. Since the ordering of the votes over one dimension, e.g., τ, is not affected by the value of the other dimension, e.g., λ, the median vote over τ and λ always coincides with the votes of a type-$E_{m\tau}$ young and a type-$E_{m\lambda}$ (young or old) individual. We can now analyze the different cases.

Case A is trivial. If $E_{m\lambda} \geq -(1-\alpha)$, then $\lambda^*=1$, and for $\lambda=1$, $\tau^*=0\ \forall\ E_{m\tau}$.

Case B is trivial too. If $E_{m\tau} \geq \hat{E}(\lambda)$, then $\tau^*=0$, and for $\tau^*=0$, if $E_{m\lambda}<-(1-\alpha)$, then $\lambda^*=0$.

Case C: If $E_{m\lambda}<-(1-\alpha)$, than $\lambda_{E_{m\lambda}}(\tau)=\max\left\{0,\frac{1}{2}-\frac{1-\alpha+E_{m\lambda}}{8\gamma E_{m\lambda}\tau(1-\tau)}\right\}$. If $E_{m\tau}<\hat{E}(\lambda)$, then $\tau_{E_{m\tau}}(\lambda)>0$. Notice that for $\lambda=0$, $\tau_{E_{m\tau}}(0)=\frac{1}{2}-\frac{1+E_{m\tau}}{2\alpha(1+N)}$. In order to have a structure induced equilibrium at $(\tau^*=\tau_{E_{m\tau}}(0)>0, \lambda^*=0)$, we thus need to have that $\lambda_{E_{m\lambda}}=0$ for $\tau_{E_{m\tau}}=\frac{1}{2}-\frac{1+E_{m\tau}}{2\alpha(1+N)}$. By substituting this value of $\tau_{E_{m\tau}}$ in $\lambda_{E_{m\tau}}(\tau)$, it easy to see that $\lambda_{E_{m\lambda}}=0$, if $E_{m\tau} \geq \Omega\ (E_{m\lambda})=-1+\alpha(1+N)\sqrt{-\frac{1}{\gamma}\left(\frac{1-\alpha}{E_{m\lambda}}+1-\gamma\right)}$.

Case D: If $E_{m\lambda}<-(1-\alpha)$ and $E_{m\tau}<\hat{E}(\lambda)$, as in case C, but $E_{m\tau}<\Omega\ (E_{m\lambda})$, there is no equilibrium at $\lambda^*=0$, since $\tau_{E_{m\tau}}(\tau=0)$ is greater than the maximum τ such that $\lambda_{E_{m\lambda}}(\tau)=0$. In other words, at $\lambda=0$, the reaction function $\tau_{E_{m\tau}}(\lambda)$, which represents the decision of the median voter $E_{m\tau}$ over τ, is above the reaction function $\lambda_{E_{m\lambda}}(\tau)$, which represents the decision of the median voter $E_{m\lambda}$ over λ. Notice that $\tau_{E_{m\tau}}(\lambda)$ is continuous and bounded above by 1/2, whereas, by Lemma 5.4, $\lambda_{E_{m\lambda}}(\tau)$ is continuous and increasing in τ (>0) for $E_{m\lambda}<-(1-\alpha)$. Therefore, the two reaction functions will cross in a point ($\tau^*>0$, $0<\lambda^*<1/2$), which constitutes a Structure Induced Equilibrium since $\tau_{E_{m\tau}}(\lambda^*)=\tau^*$ and $\lambda_{E_{m\lambda}}(\tau^*)=\lambda^*$. □

Proof of Proposition 5.6. Suppose (τ^*, λ^*) is a structure induced equilibrium outcome of the voting game with commitment. Let us define the following realization of the public history of the game:

$$X_t^0=\{h_t \in X_t | \tau_k=0, k=0,\ldots,t-1\}$$

and

$$X_t^\tau=\{h_t \in X_t | \exists\ t_0 \in \{0,1,\ldots,t-1\}: \tau_t=0\ \forall t<t_0 \text{ and } \tau_t=\tau^* \forall t \geq t_0\}$$

notice that $X_t^0 \cap X_t^\tau=\emptyset$.

Consider the following strategy $s=(s_{t,E}^Y, s_{t,E}^O)$, for a type-E young:

i) if $E \leq E_{m\tau}$

$$s_{t,E}^Y=\begin{cases}(\tau^*,\lambda_{t,E}(\tau^*)) & \text{if} \quad h_t \in X_t^0 \cup X_t^\tau \\ (0,\lambda_{t,E}(0)) & \text{if} \quad h_t \in X_t/\{X_t^0 \cup X_t^\tau\}\end{cases}$$

ii) if $E>E_{m\tau}$

$$s_{t,E}^Y=\begin{cases}(\tau_{t,E}^Y(\lambda^*),\lambda_{t,E}(\tau^*)) & \text{if} \quad h_t \in X_t^0 \cup X_t^\tau \\ (0,\lambda_{t,E}(0)) & \text{if} \quad h_t \in X_t/\{X_t^0 \cup X_t^\tau\}\end{cases}$$

and for a type-E old individual

$$s_{t,E}^O=(1/2,\lambda_{t,E}(\tau^*)) \quad \text{if} \quad h_t \in X_t$$

where $\tau_{t,E}^Y(\lambda^*)$ is defined in Lemma 5.2, and $\lambda_{t,E}$ (τ^*) in Lemma 5.4.

Since by definition of SIE, $\tau^* = \tau_{t,E_{m\tau}}(\lambda^*)$ and $\lambda^* = \lambda_{t,E_{m\lambda}}(\tau^*)$, it is easy to see that:

$$\tau^Y_{t,E}(\lambda^*) \geq \tau^* \forall\ E \leq E_{m\tau},$$
$$\lambda_{t,E}(\tau^*) \leq \lambda^* \forall\ E \leq E_{m\lambda}$$

Recall that the outcome function of the voting game at time t is the median in every dimension of the distribution of actions, (τ^m_t, λ^m_t), then it is straightforward to see that the previous strategy profile $(s^Y_{t,E}, s^O_{t,E})$ constitute a subgame perfect equilibrium of the voting game with no commitment, with equilibrium outcome (τ^*, λ^*). □

Proof of Proposition 6.1. An increase in the health care productivity, γ, increases both reaction functions $\tau_{E_{m\tau}}(\lambda)$ and $\lambda_{E_{m\lambda}}(\tau)$. To see this, notice that

$$\frac{\partial \tau_{E_{m\tau}}(\lambda)}{\partial \gamma} = -\left.\frac{\frac{\partial \mathrm{FOC}(\tau_{E_{m\tau}})}{\partial \gamma}}{\mathrm{SOC}(\tau_{E_{m\tau}})}\right|_{\tau_{E_{m\tau}}} > 0$$

since $\mathrm{SOC}(\tau_{E_{m\tau}}) < 0$, and

$$\left.\frac{\partial \mathrm{FOC}(\tau_{E_{m\tau}})}{\partial \gamma}\right|_{\tau_{E_{m\tau}}} = -8E_{m\tau}(1-\lambda)\lambda(1-2\tau)\tau(1-\tau) > 0.$$

Moreover,

$$\frac{\partial \lambda_{E_{m\lambda}}(\tau)}{\partial \gamma} = -\left.\frac{\frac{\partial \mathrm{FOC}(\lambda_{E_{m\lambda}})}{\partial \gamma}}{\mathrm{SOC}(\lambda_{E_{m\lambda}})}\right|_{\lambda_{E_{m\lambda}}} > 0$$

since $\mathrm{SOC}(\lambda_{E_{m\lambda}}) < 0$, and

$$\left.\frac{\partial \mathrm{FOC}(\lambda_{E_{m\lambda}})}{\partial \gamma}\right|_{\lambda_{E_{m\lambda}}} = -4\gamma E_{m\lambda}(1-2\lambda)\tau^2(1-\tau)^2 > 0.$$

In order for the new functions to cross in an equilibrium $(\tau^{**}, \lambda^{**})$, with a larger welfare state, $\tau^{**} > \tau^*$, and a larger share of pensions, $\lambda^{**} > \lambda^*$, we need to make sure that this crossing takes place at the left of the maximum of the $\tau_{E_{m\tau}}(\lambda)$ function (see Fig. 9). In other words, for a given τ , the reaction function $\lambda_{E_{m\lambda}}(\tau)$ (see Lemma 5.4) has to be smaller than $\lambda' = \arg\max\{\tau_{E_{m\tau}}(\lambda)\}$ (see Lemma 5.3). It is easy to see that this occurs for $E_{m\lambda} \leq \frac{2(1-\alpha)E_{m\tau}}{1-\alpha-E_{m\tau}}$. □

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