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Philippe De Donder
Marie-Louise Leroux

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Abstract

We build a political economy model where individuals differ in the extent of the behavioral bias they exhibit when voting first over social long-term care (LTC) insurance and then choosing the amount of LTC annuities. LTC annuities provide a larger return if dependent than if healthy. We study the majority voting equilibrium under three types of behavioral biases: myopia, optimism and sophisticated procrastination. Optimists and myopics similarly under-estimate their own dependency risk both when voting and when buying LTC annuities. They differ in that optimists know the correct average dependency risk (that determines the return of both social and private insurance), while myopics also under-estimate this average risk (and thus over-estimate the insurance return). Sophisticated procrastinators act as if they under-estimated their own risk when buying annuities, but anticipate this bias at the time of voting.

We obtain that the stylized observation of lack of LTC insurance is compatible with agents being optimistic or myopic, but not sophisticated procrastinators. Increasing the difference in return across dependency states for the LTC annuity is detrimental to sophisticated voters and to very biased myopic and optimist voters. Finally, less myopic individuals may end up worse off, at the majority-voting equilibrium, than more myopic agents, casting some doubt on the usefulness of information campaigns.

JEL-Code: H550, I130, D910.

Keywords: majority voting, myopia, optimism, sophisticated procrastinators, dependency linked annuity, enhanced life annuity, complementary private insurance.

Philippe De Donder
Toulouse School of Economics
Toulouse / France
philippe.dedonder@tse-fr.eu

Marie-Louise Leroux
Department of Economic Sciences, ESG
University of Québec at Montréal / Canada
leroux.marie-louise@uqam.ca

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1 Introduction

Long Term Care (LTC hereafter) "is the care for people needing support in many facets of living over a prolonged period of time. Typically, this refers to help with so-called activities of daily living, such as bathing, dressing, and getting in and out of bed" (OECD, 2011). People in need of LTC are called dependent.

LTC is an important public policy problem. According to Brown and Finkelstein (2009), in the US, between 35 and 50 percent of 65 year old will use a nursing home at some point in their remaining lives. Of those who use a nursing home, 10 to 20 percent will live there more than five years. The costs of formal LTC are also very large. Genworth (2012) surveys them for the US: in 2012, the median annual rate for a private nursing room is more than $80,000, while the median hourly rate charged for a home health aid is $19.

The issue of the financing of LTC needs will loom larger in the near future because of two trends. The first is demographic: by and large, dependency is associated with old age, so the ageing of our populations engenders an increase in the number of people requiring LTC services.[1] The second trend is sociological and economic: the increasing female participation to the labor market, the declining size of the family and the increasing distance between parents and children all lead to a decrease in the amount of informal care provided.

As argued by Brown and Finkelstein (2011, p122), "the possibility of needing long-term care is exactly the sort of large, uncertain expenditure risk for which insurance would seem to be most valuable. Yet most long-term care expenditure risk is not insured" in the US. A similar statement is made for OECD countries by OECD (2011). The share of LTC expenditures (public and private) in GDP is very small. For instance, it accounted for 1.5% of GDP on average across 25 OECD countries, in 2008. In France it accounted for 1.7% and in Canada for 1.5% (OECD Health Data 2010). These expenses consist mainly of social programs together with private insurance.[2] In a nutshell, there is very little social and especially private insurance: the share of formal LTC expenditures covered by private LTC insurance varies from roughly 0.5% in France

[1] According to the EC aging report (2009), the number of persons aged above 80 in the EU15 is expected to rise from 21 millions in 2007 to 44 millions in 2060, while the public expenditures are expected to double and the number of dependent persons to grow by 115%.

[2] Public LTC programs provide either cash benefits or in-kind services, which depend on the needs and on the financial resources of the user. Since benefits never totally cover the total cost of dependency, individuals have an incentive to complement public LTC coverage with private insurance. From now on, we use the term of "social insurance" for all such public programs. They include Medicaid in the US and the APA in France.

and Canada to a maximum of 5% to 7% in Japan and the United states.

The literature has offered several explanations for the lack of LTC insurance:[3] asymmetric information problems (both moral hazard and adverse selection) induce insurers to restrict coverage (Sloan and Norton (1997)), informal help (mainly by family members) and social insurance crowd out the demand for private insurance (Brown and Finkelstein (2008)). Private insurance is afflicted by large loading factors and inefficiencies (Brown and Finkelstein (2007, 2009)) while social insurance faces its own set of inefficiencies plus the cost of public funds.

We focus here on a different reason for the low demand for LTC insurance: behavioral biases. Brown and Finkelstein (2009), Pestieau and Ponthière (2010) and Zhou-Richter et al. (2010) mention these biases as a primary reason for the lack of LTC insurance. The following quote from OECD (2011, p.253) shows that different phenomena may be at play: "For instance, the risk associated with dependency is often deemed as too remote to warrant coverage starting at a relatively young age. Individuals' **perceptions** on the level of public support also affect the perceived need to hold private coverage. These may translate in individuals **delaying** until an older age decisions regarding the purchase of a private LTC coverage, when they are more likely to face high premia and less likely to pass underwriting tests. (our emphasis)" The first type of behavioral bias resembles procrastination: individuals delay the decision to purchase insurance until it is too late, or at the very least until it gets very costly. The second type of bias has to do with the misperception of the future level of need. Note that this misperception may come either from an under-estimation of the individual's risk of becoming dependent, or from an over-estimation of the insurance transfer received in case of dependency.

To the best of our knowledge, there is little literature trying to measure these misperceptions.[4] One notable exception is Finkelstein and McGarry (2006) who compares the subjective probability of entering a nursing home within five years for respondents aged on average 78 to the actual decisions of the same respondents after five years. They find that most respondents under-estimate their true probability of needing such a form of LTC.[5]

[3]For surveys on long term care, see Brown and Finkelstein (2011) and Cremer et al. (2009).

[4]Based on a review of several surveys, Pauly (1990) attributes the non-purchase of private LTC insurance to the fact that individuals lack awareness of the probability of how often LTC services are needed. This opinion is indirectly supported by a questionnaire conducted among financial planners by Bacon et al. (1989), in which the majority of respondents reported that their clients are unaware of the risk of a potential nursing home stay.

[5]To be fair, a non-negligeable fraction of respondents over-estimated their risk in this study. Also, comparing responses on subjective survival probabilities with actual ones, Hamermesh (1985) shows that middle aged individuals tend to underestimate their survival probability to ages below 70 years old but overestimate it for ages above 70. Ludwig and Zimper (2007) obtains similar results. Since the prevalence of dependency increases

The first objective of our paper is to clarify the meaning of these behavioral biases by proposing different ways to model them. The second objective is then to assess the impact of these behavioral biases on the demand for both public and private LTC insurance, together with self-insurance (or saving). We take this opportunity to study a financial product that has received a lot of praise recently. The OECD ranks the combination of LTC insurance with life annuities as one of "the most promising private sector innovations" (OECD 2011). Compared to traditional life annuities, a LTC annuity provides a reduced amount in case of health compensated by a larger payment once the need for LTC arises. It is also dubbed a Disability Linked Annuity (DLA, see Mayhew et al. (2010) and Rickayzen (2007)) or an enhanced life annuity (Levantesi and Menzietti (2012)). Mayhew et al. (2010) also stresses that "The potential market for DLA products is large and with over 400k new pensioner annuitants each year" (in the UK) ", DLAs could make an important contribution to LTC planning." To the best of our knowledge, such a product currently exists only in the US.

We develop a two-period political economy model where young agents vote first over social LTC insurance and then choose how much LTC annuity (or DLA) to buy. All individuals have the same probability of becoming dependent in the second period. Dependency is modeled as a monetary loss, decreasing the absolute utility level but increasing the marginal utility of income. Both social LTC insurance and DLA serve a lump sum transfer in case of dependency, while DLA also serves a (lower) payment in case of health. More precisely, the DLA is modeled as a financial asset mixing, in exogenous parts, saving (with the same return in both states of the world) and insurance (with a larger return earned only in case of dependency).

In order to concentrate on the impact of behavioral biases, we assume away all other factors that may explain a low demand for LTC insurance (no loading factor on private financial product, no cost of public funds for social insurance, no heterogeneity in risk and income so that there is no ex ante redistribution, and no family help). Since both public and private insurance (the latter offered through a DLA) are actuarially fair, their return is based on the average risk in the economy.

The behavioral biases that affect individuals translate into their putting too little weight on the probability of becoming dependent when choosing how much LTC annuity to buy. Agents differ only according to how much they under-weight this future state of the world – i.e., by

sharply with age, especially after 70, these misperceptions may lead to over-estimations of the dependency risk. We discuss in the Conclusion how over-estimation by some agents would affect our results.

their degree of behavioral bias.

This under-weighting may come from a misperception problem, when individuals under-estimate their own risk of becoming dependent. An extensive literature, covering different fields, shows that some individuals exhibit a so-called "Lake Wobegon effect, where all or nearly all of a group claim to be above average. (... It) has been observed among drivers, CEOs, hedge fund managers, presidents, coaches, radio show hosts, late night comedians, stock market analysts, college students, parents, and state education officials, among others."[6] We call agents under-estimating their own risk but assessing correctly the average, economy-wide, risk the optimists (or type O individuals).

Another type of misperception consists in under-estimating both one's own risk and the average risk of dependency in society. We call such individuals myopic (or type M). For them, dependency is simply seen as a smaller issue, in general, than what it is (or will be by the time they become old enough). It is unclear from Finkelstein and McGarry (2006) whether individuals, who mostly under-estimate their own risk, also under-estimate the average risk. We then study both myopics and optimists in the rest of the paper, and we contrast their choices. It is worth stressing that both make the same mistake(s) when voting and when buying the DLA: their two choices are consistent with each other.

Finally, the under-weighting of the probability of being dependent may arise from a procrastination problem: although they know perfectly their own (and the average) probability of becoming dependent in the future, individuals delay (as in the OECD quote above) the decision to buy LTC annuities. Observe that procrastination is much more difficult at the time of voting, since the election date is not under the control of agents. We then make the assumption that, at the time of voting, these individuals anticipate their future procrastination problem and thus use their true probability of becoming dependent. In other words, as in Cremer et al. (2007), they vote "in a state of grace". We dub these individuals the sophisticated procrastinators (or type S individuals).

We analyze the demand for social LTC insurance and annuity when all individuals are either optimistic, myopic or sophisticated. We study both the most-preferred allocation (social insurance and annuity) of individuals, as a function of their degree of behavioral bias, and the allocations chosen at the political economy equilibrium (where the amount of social insurance

[6] See wikipedia.org and the references mentioned there. See also the related Dunning–Kruger effect where agents mistakenly rate their ability much higher than average.

is decided by majority voting, while the choice of LTC annuity remains individualized). As a normative criterion, we use the utility function of an individual not suffering from any behavioral bias to evaluate the welfare attained by individuals at their (more or less biased) choices. Here is a quick overview of our main results.

The socially optimal allocation (chosen by an individual without any behavioral bias) consists in an amount of insurance that covers exactly the dependency loss (and thus equalizes second-period marginal utilities in the two states of the world), coupled with an amount of saving that equalizes marginal utilities in the first and second period. The saving vs insurance content of the DLA determines the optimal mix of private and social insurance.

Optimists and myopics are much closer to each other, in terms of demand for social LTC insurance and annuity, than to sophisticated procrastinators. All M and O individuals favor too little social LTC insurance (so that the amount chosen at the majority is also sub-optimal), but for different reasons: type M because they over-estimate the insurance transfer received in case of dependency, type O because they consider insurance to be actuarially unfair to them. As for the LTC annuity, both types consume too much of it at their most-preferred (insurance, saving) allocation, but too little at the majority voting equilibrium given the value of the social insurance contribution rate chosen. The annuity level at their most-preferred (insurance, saving) allocation is too large because, by favoring too little social insurance, they bias the marginal utility of first-period consumption downwards while biasing the marginal utility of second-period consumption if dependent upwards (compared to the socially optimal levels). By contrast, the amount of annuity chosen when social insurance is set at its majority-chosen level is too small, given this contribution rate, because both types M and O put too little weight on the dependency state, where marginal utility is larger than if healthy because of the low level of social insurance.

The share of the DLA consisting of insurance has no impact on types M and O's utility at their most-preferred allocation, because individuals adjust their preference for social insurance and for DLAs in order to maintain the total insurance amount, and total saving, constant. In the extreme case where the DLA is a pure insurance product, the majority voting equilibrium with optimists or myopics consists in no social insurance and individuals buying too little private insurance. This result is driven by the assumption that O and M make the same mistake when voting and when buying privately, so that they see no point in forcing themselves to consume more insurance at the voting stage.

The results obtained with type S agents differ starkly according to whether the DLA is pure saving, or offers a larger return when dependent. In the former case, all S individuals obtain (both at their most-preferred bundle and at the majority voting equilibrium) the socially optimal allocation: anticipating their future mistake, they unanimously vote for a social insurance amount equal to the dependency loss, thus equalizing second-period marginal utilities. The mistake made when choosing the amount of annuity is then immaterial, since it does not affect the expected marginal benefit from the annuity, and they unanimously favor the socially optimal saving amount as well. When the DLA offers a higher return when dependent, it becomes more difficult to disentangle saving from insurance, which prevents S individuals from perfectly correcting their procrastination. They then choose different allocations according to their degree of procrastination. In stark contrast with the O and M agents, they prefer too little DLA and too much social insurance at their most-preferred bundle: because they are sophisticated, procrastinators anticipate that they will buy too little annuity and counteract this by favoring more social insurance than would be optimal.

In the second-best world where DLA is pure insurance (so that no saving technology exists), S individuals choose the second-best optimal amount of social insurance and do not buy any private insurance at equilibrium: anticipating that they will buy too little DLA, they unanimously force themselves by vote to consume all the required insurance from the social program.

We discuss in the concluding section how our results shed light on stylized facts, and the policy recommendations that they suggest.

We now provide a brief overview of the related literature. Our paper is linked to two emerging strands of the political economy literature.[7] The first one consists of political economy models of LTC. Nuscheler and Roeder (2010)'s aim is to explain income redistribution and public financing of LTC, in a setting where voters differ in income and in LTC needs and where a proportional income tax finances both a lump sum and a LTC transfer. This creates two conflicts: between poor and rich voters, over the value of the tax rate, and between individuals with low and high LTC needs, over how to use the tax proceeds. Their majority voting equilibrium exhibits the negative association between income inequality and LTC financing that they find in the data.

[7] Cremer and Roeder (2012) takes a normative perspective and examines whether misperception of individual LTC risks and private insurance market loading costs can justify social LTC insurance and/or subsidization of private insurance. Although they use the term of myopia, their agents are indeed optimistic since they correctly estimate the average dependency rate in the economy. They differ in their degree of bias, income and dependency risk, with the latter two positively and perfectly correlated.

De Donder and Pestieau (2011) studies the determinants of the demand for public and private LTC insurance, when individuals differ in income, in risk and in access to informal care. They derive the political support for public LTC insurance and show how the availability of private insurance, the size of family help and the correlation between individual characteristics affect the majority voting level of public LTC insurance.

The second strand of political economy literature deals with agents having self-control problems. Cremer et al. (2007) models an economy composed of both rational individuals and sophisticated procrastinators, who also differ in income, and who vote over the size and the degree of income redistribution of the pay-as-you-go pension system. Their main result is that the size of the pension system is not monotone in the proportion of sophisticated procrastinators, because of induced changes in the degree of redistributiveness of the pension system. We differ from this paper on many grounds, the most obvious being that we consider agents differing both in their type of behavioral bias (myopics, optimists and sophisticated procrastinators) and in the intensity of their bias, while Cremer at al. (2007) considers that individuals differ in income but exhibit no "intermediate" degree of behavioral bias: either individuals perfectly anticipate their retirement needs, or they do not at all.

Another related paper is Haavio and Kotaporpi (2009) which compares the level of the optimal sin tax with the level chosen at the majority when individuals have different degrees of self-control problems. As in Cremer et al. (2007), they assume that agents are sophisticated when voting, but they allow for a continuous distribution of the degree of behavioral bias. To the best of our knowledge, our paper is then the first to provide a political economy analysis with both different types and different degrees of behavioral biases.

The paper is organized as follows. We describe the model and individuals' preferences in section 2. We study the socially optimal allocation in section 3. We then solve the model by backward induction, starting with the choice of DLA in section 4. We study the amount of social LTC insurance chosen at equilibrium in the next sections. We first assume that the DLA contains at least some saving element, and we solve for the equilibrium when individuals are myopic (section 5), optimistic (section 6) and sophisticated procrastinators (section 7). We then study the pure insurance case in section 8, before drawing the main implications of our analysis in section 9.

2 The model

We develop a two-period model with a mass one of individuals. In the first period, individuals are young and all earn the same income w. They choose how much to consume and how much LTC annuity to buy. In the second period, individuals are old and face the same probability π to be dependent and $(1-\pi)$ to remain autonomous. They take no decisions when old.

Young individuals pay a tax τ on their income so as to finance a social LTC program that serves a lump sum benefit in case of dependency. The budget balance equation of this program depends crucially on the average probability of becoming dependent (which, by the low of large numbers, equals the proportion of elderly who will become dependent). Because of the behavioral biases (detailed at greater length later) exhibited by the agents, it is important to distinguish the correct average dependency rate, π, from the perceived one, which we denote by $\bar{\pi}$. The budget constraint, as perceived by an individual, is given by

$$b(\bar{\pi}) = \frac{\tau w}{\bar{\pi}}, \tag{1}$$

with the correct budget constraint given by $b(\pi)$.

In the first period of their life, individuals decide how much to invest in a LTC annuity. This annuity is a private financial product which yields a return differentiated upon the health condition of the individual. The perceived return of this annuity is $R^h(\gamma)$ in case of autonomy (good health), with

$$R^h(\gamma) = R(1-\gamma), \tag{2}$$

and $R^d(\gamma, \bar{\pi})$ in case of dependency, with

$$R^d(\gamma, \bar{\pi}) = \frac{R}{\bar{\pi}}\gamma + (1-\gamma)\, R \geq R^h, \tag{3}$$

where the gross interest rate R is without loss of generality set to one. The exogenous parameter $\gamma \in [0,1]$ represents the fraction of the annuity made of insurance while the remaining part $(1-\gamma)$ is the fraction devoted to saving. When $\gamma = 0$, we have pure saving since the return from investing in the private annuity is independent of the health condition of the agent and equals the gross interest rate. When $\gamma = 1$, we have pure insurance since the individual gets nothing if healthy but a gross return of $1/\bar{\pi} > 1$ if dependent. The return when autonomous is decreasing in γ while the return in case of dependency is increasing in γ. Finally, the return is decreasing in the perceived average prevalence of dependency, $\bar{\pi}$, when $\gamma > 0$.

An agent's true (or correct) utility function is given by:

$$W = u(c) + (1-\pi)\, u(d^h) + (\pi v d^d(\pi)) \quad (4)$$
$$\text{with} \begin{cases} c = w(1-\tau) - a \\ d^h = R^h(\gamma)a \\ d^d(\pi) = R^d(\gamma,\pi)a + b(\pi) \end{cases}$$

where c is first-period consumption, d^h and $d^d(\pi)$ are second-period consumptions in case of, respectively, autonomy and dependency, and a denotes the amount of LTC annuity bought by the individual.

We assume that both the utility function in case of autonomy, $u(.)$, and in case of health, $v(.)$, are increasing and concave: $u' > 0$, $u'' < 0$, $u'(0) = \infty$, $v' > 0$ and $v'' < 0$. Moreover, we assume that

$$u(x) > v(x) \text{ and } u'(x) < v'(x), \ \forall x. \quad (5)$$

These assumptions reflect the observations that, for any consumption level, individuals are worse off if dependent than if healthy, but have higher needs (i.e. higher marginal utility from consumption).[8] One class of family functions satisfying these assumptions is given by

$$v(x) = u(x - L), \quad (6)$$

i.e., becoming dependent is equivalent to suffering a monetary loss $L > 0$. In order to simplify calculations, we assume in the rest of the paper that (6) holds, but our results would hold qualitatively more generally provided that the inequalities (5) are satisfied.

As for the sequence of decisions, we assume that young individuals vote first over the value of the social LTC insurance contribution rate, τ, that they observe the majority chosen level, and that they then privately decide the amount of private LTC annuity that they wish to buy, a.[9]

[8] This assumption may be disputed (see for instance Finkelstein et al. (2008)) since some goods may substitute or complement good health. Observe that if dependent people do not have higher marginal utility than when healthy, the lack of demand for LTC insurance is not puzzling at all.

[9] The transfer received by agents when old is determined by their contribution when young. Since any change in the contribution rate affects the future payments received by the currently young agents, agents vote only when young. Alternatively, we could study an overlapping-generation model with a pay-as-you-go LTC insurance, where variations in τ impact both the (currently) young and old agents. In that case, old agents would either be indifferent as to the value of τ (if healthy at the time of voting), or favor the maximum value of τ (if dependent). As for young agents, their preference would depend on the perceived link between current contribution and future transfer. Such considerations are well known in the political economy literature on pensions (see Sjoblom 1985), and we abstract from them here.

As explained in the introduction, we consider and contrast three distinct forms of behavioral biases. All have in common that they under-estimate their probability of becoming dependent by a factor α when choosing how much annuity to buy. More precisely, they consider their probability to become dependent as $\alpha\pi$ rather than π. Agents differ according to this bias parameter α, which is distributed in the economy on the interval $]0, 1]$ with a median value denoted by α_{med}.[10]

Sophisticated procrastinators anticipate this mistake when voting over the social insurance tax rate: they use the correct probability π of being dependent when voting over τ, anticipating that they will use biased probabilities $\alpha\pi$ when deciding later over a. With this interpretation, there is no reason for S individuals to misestimate the aggregate probability of being dependent, so that they use $\bar{\pi} = \pi$ in both their private and public choice. We represent the parameters used by sophisticated individuals in both choices in the first row of Table 1.

Type	Choice	Weight on d state	Perceived average risk $\bar{\pi}$
S	vote over τ	π	π
	choice of a	$\alpha\pi$	π
O	vote over τ	$\alpha\pi$	π
	choice of a	$\alpha\pi$	π
M	vote over τ	$\alpha\pi$	$\alpha\pi$
	choice of a	$\alpha\pi$	$\alpha\pi$

Table 1: Parameters used by individuals in both decisions

Another type of behavioral bias consists in being optimistic, anticipating correctly the average probability of dependency π while under-estimating one's own risk as $\alpha\pi$. We report in the second set of rows of Table 1 the parameter values that type O agents use in both choices. Note that, contrary to sophisticated procrastinators, optimists make the same mistakes (i.e., use the same probabilities) when voting over τ and deciding privately over a. Procrastinators who would make the same mistake when voting and when buying LTC annuities would behave identically to the optimists.

The last type of behavioral bias that we consider is myopia, where agents similarly under-estimate both their individual and the average probability of becoming dependent. Since myopics under-estimate the future prevalence of LTC for all individuals in the economy, and do not

[10]In the rest of the paper, we assume that no agent is totally myopic, that is to say, they all believe that they have at least a very small chance of becoming dependent: $\alpha > 0$ for all. This is a reasonable assumption that allows to simplify our analysis since we can disregard any discontinuity in saving or voting behavior when $\alpha = 0$. In the conclusion, we discuss how our results would be affected if some agents over-estimated their risk, $\alpha > 1$.

consider themselves to be different from others, they use $\alpha\pi$ as both their individual and average probability. As shown in Table 1, type M individuals use the same probabilities both when voting and when buying LTC annuities. Type M is the only type making a mistake when anticipating the return of both social insurance and the LTC annuity (at least as long as it embodies some insurance characteristics–i.e., when $\gamma > 0$).

Since we only consider two levels of $\bar{\pi}$, we simplify our notation and denote by R^d, d^d and b the correct levels of return, consumption and transfers (i.e., $R^d = R^d(\gamma, \pi)$, $d^d = d^d(\pi)$ and $b = b(\pi)$) and we use a tilde to denote the levels that are misconstrued by myopics (i.e., $\tilde{R}^d = R^d(\gamma, \alpha\pi)$, $\tilde{b} = b(\alpha\pi)$ and $\tilde{d}^d = d^d(\alpha\pi)$). It is easy to see that $\tilde{R}^d > R^d$, $\tilde{b} > b$ and $\tilde{d}^d > d^d$ since M individuals over-estimate the return of social insurance and LTC annuities and thus the transfers (public and private) that they will receive in case of dependency.

Finally, note that we assume that society is homogenous in the sense that it consists exclusively of agents of either type S, type M or type O. In other words, we leave for future research the case where individuals of different types of behavioral biases coexist to concentrate on a society made of individuals differing only in the intensity (as measured by α) of a given behavioral bias (procrastination, optimism or myopia).

We start by identifying the socially optimal allocation in this economy.

3 The socially optimal allocation

The socially optimal allocation corresponds to the allocation (c, d^h, d^d) that maximizes (4). It corresponds to the allocation chosen by an individual without behavioral bias (i.e., with $\alpha = 1$). It is easy to show that the optimal allocation is such that marginal utilities are equalized across states of nature:

$$u'(c) = u'(d^h) = v'(d^d).$$

Equalizing marginal utilities across periods and states of the world requires two types of transfers. We denote by S the amount of saving (i.e., second-period transfer enjoyed whether dependent or not) and by I the total amount of (public and private) insurance (i.e., transfer received only if dependent):

$$\begin{aligned} S(\gamma, a) &= (1-\gamma)a, \\ I(\gamma, \tau, a) &= \frac{\tau w + \gamma a}{\pi}. \end{aligned}$$

Saving corresponds to the share $1-\gamma$ of the LTC annuity, while insurance is made of both social insurance (financed with τ) and of the share γ of the LTC annuity, with the total "premia" $\tau w+\gamma a$ sharing the same return, $1/\pi$. Denoting the optimal values of variables by the superscript *opt*, we then obtain that

$$\begin{aligned} S^{opt} &= S(\gamma, a^{opt}) = \frac{w-\pi L}{2}, \\ I^{opt} &= I(\gamma, \tau^{opt}, a^{opt}) = L. \end{aligned}$$

The socially optimal amount of insurance corresponds to the LTC loss, L, equalizing marginal utilities in the two states of the world in the second period. The optimal saving amount equalizes marginal utility across periods. As for the comparative statics analysis, all variations that raise the marginal utility from first-period consumption decrease the socially optimal amount of saving: a lower income w and larger values of π and L (since they both require larger first-period payments for the total insurance transfer to equal L). In the rest of the paper, we assume that the socially optimal allocation is feasible– i.e., that $w > \pi L$. We denote by W^{opt} the utility level attained at this socially optimal allocation.

This optimal allocation can be decentralized by choosing

$$a^{opt}(\gamma) = \frac{w-\pi L}{2(1-\gamma)}, \tag{7}$$

$$\tau^{opt}(\gamma) = \frac{\pi L(2-\gamma)-\gamma w}{2(1-\gamma)w}, \tag{8}$$

provided that $\gamma < 1$, namely that the LTC annuity contains at least a part of saving.

The comparative statics of a^{opt} is obvious from above, because buying annuities is the only way to save, while that pertaining to τ^{opt} is more convoluted since, when $\gamma > 0$, LTC insurance can also be obtained by buying annuities. A larger value of L increases τ^{opt}, both directly because of larger needs but also indirectly because of the induced decrease in the optimal amount of annuity (and thus of private insurance when $\gamma > 0$). A similar result is obtained for the return of insurance, π. A larger value of w decreases τ^{opt}, because it simultaneously increases the return of the social insurance contribution rate while decreasing the need for social insurance since individuals buy more annuities (and thus more private insurance when $\gamma > 0$).

A larger fraction of insurance in the annuity, γ, increases the optimal amount of annuities a^{opt} while decreasing the optimal value of τ. Decentralization of the socially optimal allocation then entails buying more annuities (to maintain the total amount of saving constant at its optimal level) together with less social insurance (in order to compensate the larger amount of private insurance and to maintain total, private plus public, insurance constant as well). As γ increases, the share of insurance coming from private sources (the annuity) increases at the expense of social insurance.

Observe also that it is not possible to decentralize the social optimum when γ becomes too large, since in that case the required amount of annuities may bankrupt the individual, and τ^{opt} may become negative since the large amount of annuities bought generates more private insurance than the social optimal level.

A case of particular interest arises when $\gamma = 1$, so that saving is (by assumption) not available in the economy. The second-best socially optimal allocation is then given by the condition

$$u'(c) = v'(d^d) < u'(d^h),$$

and we have

$$I^{SB} = \frac{w}{1+\pi}(1 + \frac{L}{w}) > L \tag{9}$$

when $S^{opt} > 0$, where the superscript SB stands for second-best. Note that in that case there is a continuum of values of a and τ that are second-best optimal, since it is total insurance that matters. Because of the missing instrument, utility is lower at the second-best than at first-best.

We now turn to the equilibrium with behavioral biases. We solve the individual optimization program using backward induction, starting with the LTC private annuity choice.

4 The private choice of life/LTC annuity

At the time of choosing how much LTC annuity to buy, the utility of an agent is denoted by[11]

$$\begin{aligned} U^a(\alpha, \gamma, \tau, \bar{\pi}) &= u\left(w\left(1-\tau\right)-a\right) \\ &\quad + \left(1-\alpha\pi\right) u\left(R^h(\gamma)a\right) + \alpha\pi v\left(b(\bar{\pi}) + R^d(\gamma, \bar{\pi})a\right), \end{aligned}$$

where the value of τ is considered as exogenous. Both the public and the private transfers are obtained using the return perceived by the individual, as given by (1), (2) and (3) respectively.

[11] We use the superscript a on the utility function to remind the reader that this is the utility function used when taking the private annuity decision, since this utility function differs from the correct utility function W of the agent. We write this utility function so as to encompass all three possible types of behavioral bias: procrastination, optimism and myopia.

Since $u'(0) = \infty$, the first-order condition with respect to a is given by the interior solution[12]

$$u'(c) = (1 - \alpha\pi) R^h(\gamma) u'\left(d^h\right) + \alpha\pi R^d(\gamma, \bar{\pi}) v'\left(d^d(\bar{\pi})\right). \tag{10}$$

Intuitively, individuals plan to equalize the marginal cost and benefit of the annuity, with the latter reflecting the probability of each future state of the world, and the state-dependent marginal utility and annuity return. Behavioral biases translate into too large a weight being given to the autonomous state (for all types of agents), and, for myopics only, into a misperception of both the annuity return in case of dependency (when $\gamma > 0$) and of the consumption level in that state (because of over-estimation of both $b(\bar{\pi})$ and $R^d(\gamma, \bar{\pi})a$).

Denoting by $a^*(\alpha, \gamma, \tau, \bar{\pi})$ the optimal saving decision and using the implicit function theorem on (10), we obtain that

$$\frac{da^*(\alpha, \gamma, \tau, \bar{\pi})}{d\tau} \overset{s}{=} \frac{\partial U^a}{\partial a \partial \tau} = u''(c)\, w + \alpha \frac{\pi}{\bar{\pi}} R^d(\gamma, \bar{\pi}) v''\left(d^d(\bar{\pi})\right) w < 0.$$

This result establishes the substitutability between private LTC annuities and social insurance at the equilibrium. A larger social LTC insurance program raises the marginal (first-period) utility cost of a private LTC annuity and decreases its expected marginal (second-period) utility benefit, leading to a lower level of LTC annuity. Observe that this result holds whatever the value of γ, including the polar cases of pure insurance ($\gamma = 1$) and pure saving ($\gamma = 0$).

At this level of generality (and especially given that τ can take any value), it is not possible to sign the derivative of $a^*(\alpha, \gamma, \tau, \bar{\pi})$ with respect to either α, γ or $\bar{\pi}$.

When choosing their individually optimal saving amount, sophisticated procrastinators and optimists of the same degree of behavioral bias take the same decision, since they both use the correct return for both the public and private transfers. Denoting variables pertaining to a sophisticated individual with a lowerscript of S, and of an optimist with O, we obtain that

$$U^a_S(\alpha, \gamma, \tau) = U^a_O(\alpha, \gamma, \tau) = U^a(\alpha, \gamma, \tau, \pi),$$

so that

$$a^*_S(\alpha, \gamma, \tau) = a^*_O(\alpha, \gamma, \tau) = a^*(\alpha, \gamma, \tau, \pi),$$

while the myopic's objective when buying annuities is denoted with a lowerscript M:

$$U^a_M(\alpha, \gamma, \tau) = U^a(\alpha, \gamma, \tau, \alpha\pi),$$

[12]The second order condition is satisfied.

so that

$$a_M^*(\alpha,\gamma,\tau) = a^*(\alpha,\gamma,\tau,\alpha\pi).$$

We proceed to the choice by majority voting of the social LTC insurance level. We start by studying the case where all individuals are myopic (section 5) before moving to the cases where they are optimistic (section 6) and then sophisticated (section 7). In these three sections, we assume that $\gamma < 1$, so that savings are available through the purchase of annuities. We treat in section 8 the specific case where only insurance is available ($\gamma = 1$).

5 The myopics

The (perceived) indirect utility function of myopics (who similarly under-estimate average and individual LTC risks) at the time of voting is given by

$$\begin{aligned} V_M(\alpha,\gamma,\tau) &= u\left(w\left(1-\tau\right) - a_M^*(\alpha,\gamma,\tau)\right) \\ &\quad + (1-\alpha\pi)\, u\left(R^h(\gamma) a_M^*(\alpha,\gamma,\tau)\right) + \alpha\pi v\left(\tilde{b} + \tilde{R}^d a_M^*(\alpha,\gamma,\tau)\right), \end{aligned}$$

where recall that $\tilde{R}^d = R^d(\gamma,\alpha\pi)$, $\tilde{b} = b(\alpha\pi) =$ and $\tilde{d}^d = d^d(\alpha\pi)$.

We first determine the individually optimal annuity and social insurance choices of agents, before studying the properties of the majority voting equilibrium.

5.1 The optimal annuity and social insurance choices

Differentiating V_M with respect to τ, and making use of the envelope theorem for the choice of a^*, we obtain the following FOC

$$\frac{\partial V_M(\alpha,\gamma,\tau)}{\partial\tau} = w\left[v'(\tilde{d}^d) - u'(c)\right] = 0. \tag{11}$$

The intuition for this result is that M individuals consider the social LTC insurance as actuarially fair, since it is based on the same (misperceived) average risk as the individual risk, $\alpha\pi$. They use social insurance to equalize perceived marginal utilities in the first period and if dependent. Observe that the only way myopia intervenes in this formula is through $\tilde{d}^d$: M individuals do not weight their marginal utility if dependent by α, because the under-estimation of the average risk neutralizes the under-estimation of their own risk. Observe also that (11) holds whatever the value of γ.

Using conditions (10) and (11), we obtain

$$u'(c) = u'(d^h) = v'(\tilde{d}^d) < v'(d^d), \tag{12}$$

so that

$$\begin{aligned} a_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma)) &= \frac{w - \pi\alpha L}{2(1-\gamma)} && (13) \\ \tau_M^*(\alpha, \gamma) &= \frac{\pi\alpha L(2-\gamma) - \gamma w}{2w(1-\gamma)}. && (14) \end{aligned}$$

Comparing these choices with their optimal values (7) and (8), we see that M individuals act as if they faced a monetary loss, in case of dependency, of αL rather than L. It is well known that risk averse agents fully insure themselves when offered an actuarially fair insurance contract (see Mossin(1968)) and this is what myopics think they are doing, as shown by computing their perceived insurance $\tilde{I}_M^*$ and (perceived and actual) saving amounts S_M^* at equilibrium:

$$\begin{aligned} \tilde{I}_M^*(\alpha, \gamma) &= \frac{\tau_M^*(\alpha, \gamma)w + \gamma a_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma))}{\alpha\pi} \\ &= \alpha L. && (15) \end{aligned}$$

and

$$\begin{aligned} S_M^*(\alpha, \gamma) &= (1-\gamma)a_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma)) \\ &= \frac{w - \alpha\pi L}{2} && (16) \end{aligned}$$

As for saving, they actually save too much compared to the social optimum (and buy too much LTC annuity). Looking back at condition (12), we see that they end up with too little consumption in the case they become dependent: optimality would require larger payments for insurance (either public or private) in the first period, which would increase marginal utility in the first period and thus decrease the amount of saving purchased compared to (16). Observe that the actual amount of insurance payment received at the most-preferred allocation, I_M^*,will be even lower than optimal, since

$$\begin{aligned} I_M^*(\alpha, \gamma) &= \frac{\tau_M^*(\alpha, \gamma)w + \gamma a_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma))}{\pi} \\ &= \alpha \tilde{I}_M^*(\alpha, \gamma). \end{aligned}$$

We now look at how myopics' most-preferred allocation varies with γ and with α. We have that

$$\frac{da_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma))}{d\gamma} > 0 \text{ and } \frac{d\tau_M^*(\alpha, \gamma)}{d\gamma} < 0.$$

As the share of insurance in the LTC annuity increases, agents react by increasing the amount of annuity bought and by decreasing their most-preferred level of social insurance. It is easy to see from (16) and (15) that myopics keep their most-preferred levels of saving and (perceived) insurance constant as γ increases. In order to keep total saving $S_M^*(\alpha, \gamma)$ constant, they have to increase the amount of annuity bought as the share of saving in the LTC annuity decreases when γ increases. But buying more annuity, together with a larger share of insurance in this annuity, means that they also buy more private insurance. To compensate this increase and keep the total amount of perceived insurance, $\tilde{I}_M^*(\alpha, \gamma)$, constant, they then decrease their most-preferred level of τ as γ increases. Observe that the actual insurance amount and the (perceived or actual) utility levels of myopics are not affected by γ either.[13]

As for the comparative statics with respect to α, we obtain that

$$\frac{da_M^*\left(\alpha, \gamma, \tau_M^*(\alpha, \gamma)\right)}{d\alpha} < 0 \text{ and } \frac{d\tau_M^*(\alpha, \gamma)}{d\alpha} > 0.$$

As individuals become less myopic (i.e., as α increases), they increase their most-preferred level of perceived (and thus real) insurance (see (15)). It is interesting to note that this increase comes exclusively from a larger most-preferred social insurance contribution rate, at the expense of the private LTC annuity. The mechanism at play is the following: the increase in the amount of most-preferred total insurance raises the marginal utility in the first period, driving the individual to prefer a lower level of saving (see (16)). The only way to decrease this saving amount consists in buying fewer LTC annuities. This in turn means that the agent will enjoy lower private insurance transfers, and in order to increase the total amount of insurance the individual raises his most-preferred value of τ.

In order to assess normatively the equilibrium allocation chosen by individuals with behavioral biases, we use the utility function that a rational agent would use (i.e., the function W as defined in (4)), but measured of course at the allocation chosen by the (non rational) agents. With some slight abuse of notation, we denote this utility level by

$$W_M^*(\alpha, \gamma) = W(a_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma)), \tau_M^*(\alpha, \gamma)).$$

It is straightforward from the above analysis that $W_M^*(\alpha, \gamma)$ is independent of γ but increases with α. Both the choices of $a_M^*(\alpha, \gamma, \tau_M^*(\alpha, \gamma))$, $\tau_M^*(\alpha, \gamma)$ and the real utility level converge to their socially optimal levels as α tends toward one.

[13] In the rest of section 5, we concentrate on values of γ that are low enough that $\tau_M^*\left(\alpha, \gamma\right)$ is positive. For large enough values of γ, the non-negativity constraint on $\tau_M^*\left(\alpha, \gamma\right)$ becomes binding.

We now move to the majority voting equilibrium.

5.2 The majority voting equilibrium

When voting over τ, individual preferences are single-peaked in τ because the SOC holds, so that the median voter is decisive. The median voter is the individual with the median value of α. We summarize the main results obtained so far for myopics in the next proposition.

Proposition 1 *When individuals are myopic and $\gamma < 1$, they buy too much annuity and favor too little social (and total) insurance at their most-preferred allocation (compared to the socially optimal one). As γ increases, they buy more annuities and favor less social insurance in order to keep total saving and insurance constant, so that $W_M^*(\alpha, \gamma)$ remains constant as well. As they become less myopic (i.e., as α increases), they buy less LTC annuity and favor more social insurance, increasing (perceived and real) total insurance, moving closer to the optimal allocation, and increasing $W_M^*(\alpha, \gamma)$.*
The majority-chosen value of τ is

$$\tau_M^V(\gamma) = \frac{\pi \alpha_{med} L(2-\gamma) - \gamma w}{2w(1-\gamma)}.$$

In the rest of this section, we study the behavior of the real utility of agents at the majority voting equilibrium, as defined by

$$W_M^V(\alpha, \gamma) = W(a_M^*(\alpha, \gamma, \tau_M^V(\gamma)), \tau_M^V(\gamma)).$$

We answer sequentially the following three questions. First, are myopics always better off at their individually most-preferred bundle than at the majority voting equilibrium? Second, are less myopic individuals always better off than more myopic individuals? Third, how does the myopics' real utility at the majority voting equilibrium vary with γ? To make our argument crisper, we focus on the case where $\gamma = 0$ to answer the first two questions.[14]

We start by explaining why very myopic agents are actually better off when the choice of τ is imposed by majority voting, rather than chosen freely by the agent–i.e., that $W_M^V(\alpha, 0) > W_M^*(\alpha, 0)$. When left to their own devices, myopics buy too much annuity (and save too much) and too little social (and total) insurance. Very myopic individuals ($\alpha < \alpha_{med}$) are forced

[14]Arguments are more convoluted when $0 < \gamma < 1$ because one cannot separate the choice of insurance (at the voting stage) and of saving (at the annuity choice stage). Numerical examples detailed in Assumption 1 on page 20 suggest that similar results hold for any value of $\gamma < 1$.

to consume more insurance than they would wish (although less than what would be socially optimal, with $\tau_M^*(\alpha,0) < \tau_M^V(0) < \tau^{opt}(0)$), which induces them to reduce their over-saving,[15] meaning that they move closer to the socially optimal allocation and end up better off at the majority voting equilibrium than at their most-preferred bundle $(a_M^*(\alpha,0,\tau_M^*(\alpha,0)),\tau_M^*(\alpha,0))$, so that $W_M^V(\alpha,0) > W_M^*(\alpha,0)$. By opposition, agents who are less myopic than the decisive voter ($\alpha > \alpha_{med}$) are forced to consume even less social insurance than they would wish (since $\tau_M^V(0) < \tau_M^*(\alpha,0)$), and they react to this lower value of τ by buying more annuity, resulting in more over-saving and more under-insurance (compared to the optimal choice of a rational individual) than at $(a_M^*(\alpha,0,\tau_M^*(\alpha,0)),\tau_M^*(\alpha,0))$, so that $W_M^V(\alpha,0) < W_M^*(\alpha,0)$.

We now look at how $W_M^V(\alpha,0)$ varies with the degree of myopia α. This depends on how individuals adapt their saving choice, for $\tau = \tau_M^V(0)$, as a function of α. Observe first that myopics save too little, given τ, when τ is set at $\tau_M^V(0)$.[16] When deciding their amount of saving, myopics make two distinct mistakes: they put too much weight on the healthy state as compared to the dependent state, and they over-estimate the transfer received in case of dependency. The second effect clearly leads them to under-state the marginal benefit of saving (because they under-value the marginal utility when dependent). The first effect goes in the same direction, since the (correct) insurance transfer is too low to compensate the LTC loss (since, at $\tau = \tau_M^V(0)$, we have $b = \alpha_{med}L$), so that marginal utility is lower when healthy than when dependent. Since myopics under-estimate the marginal benefit of saving, they save too little at the majority voting equilibrium.

As for how saving varies with the myopia degree, using the implicit function theorem, we obtain

$$\begin{aligned}\frac{da_M^*(\alpha,\gamma,\tau)}{d\alpha} &\overset{s}{=} \frac{\partial V_M}{\partial a\partial\alpha}\\ &= \pi(v'(\tilde{d}^d) - u'(d^h)) + \alpha\pi v''(\tilde{d}^d)\frac{\partial\tilde{d}^d}{\partial\alpha}. \qquad (17)\end{aligned}$$

Increasing α has two effects on the net marginal benefit of saving: it increases the relative weight put on dependency relative to the autonomous state (the first term in (17)) while it decreases the perceived return from social insurance (the second term in (17)). While the

[15] Recall from section 4 that annuities and social insurance are substitutes for all agents, so that $da_M^*(\alpha,\gamma,\tau)/d\tau < 0$.

[16] This statement is proved in the Appendix. It does not contradict Proposition 1, since we look here at the optimal saving amount for a given value of τ, while Proposition 1 compares equilibrium and optimal bundles of saving and social insurance tax rate.

second term is unambiguously positive (because of the higher perceived marginal utility when dependent), the sign of the first term depends on the value of α. More myopic individuals over-estimate more the social insurance transfer and thus under-estimate more their marginal utility when dependent. Since $\tilde{b} = (\alpha_{med}/\alpha)L$ at the majority voting equilibrium, the first term in (17) is negative for $\alpha < \alpha_{med}$ and positive for $\alpha > \alpha_{med}$.

The two effects reinforce each other for agents who are less myopic than the median ($\alpha > \alpha_{med}$) so that their saving unambiguously increases with α. We then obtain that $W_M^V(\alpha, 0)$ increases with α for these individuals, although it remains lower than $W_M^*(\alpha, 0)$. Obviously, $W_M^*(\alpha, 0)$ converges to the first best utility level as α tends toward one, while $W_M^V(\alpha, 0)$ remains inferior.

As for individuals who are more myopic than the median ($\alpha < \alpha_{med}$), we cannot unambiguously sign the derivative of $W_M^V(\alpha, 0)$ with respect to α, because their saving amount may actually decrease with α (with the first effect in (17) being negative). We then resort to numerical examples to show that the counter-intuitive result that becoming less myopic may actually hurt some individuals at the voting equilibrium is a real possibility.

Throughout the paper, when we complement or illustrate analytical results with numerical examples, they are based on the functional forms and parameter values detailed in Assumption 1.

Assumption 1 *We assume $u(x) = Log(x)$, $w = 2$, $\pi = 0.25$, $\alpha_{med} = 1/2$ and L varying between 0.5 and 2.*

We obtain numerically that saving is first decreasing and then increasing with α: when α is very low, the second term in (17) is small enough that the first term determines the negative sign of the whole expression, and $W_M^V(\alpha, 0)$ is U shaped in α.

We summarize these two results in the following proposition, and we illustrate them in Figure 1, based on Assumption 1 with $L = 0.5$.

Proposition 2 *Assume that individuals are myopic and offered a pure saving product ($\gamma = 0$). (i) For M individuals who are more myopic than the median ($\alpha < \alpha_{med}$), we have*

$$W_M^V(\alpha, 0) > W_M^*(\alpha, 0)$$

and $W_M^V(\alpha, 0)$ *may decrease as they become less myopic.*

(ii) For M individuals who are less myopic than the median ($\alpha > \alpha_{med}$)*, we have*

$$W_M^V(\alpha, 0) < W_M^*(\alpha, 0)$$

and $W_M^V(\alpha, 0)$ *always increases as they become less myopic.*

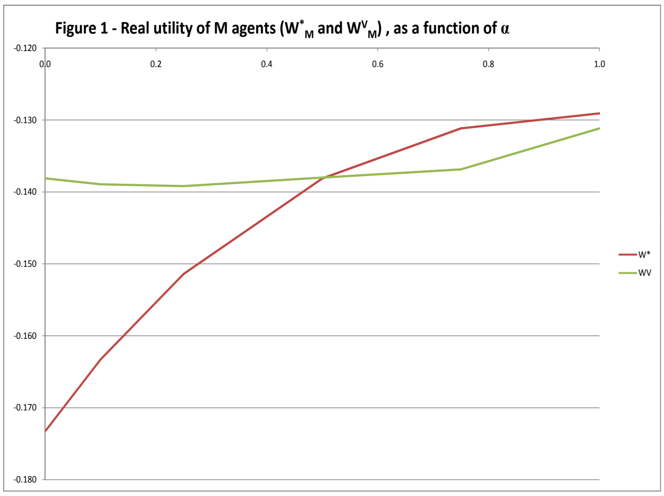

Figure 1 - Real utility of M agents (W^*_M and W^V_M) , as a function of α

We now turn to the impact of γ on M agent's utilities. We have already seen that γ does not impact the real utility level reached by myopics when they choose both their most-preferred values of LTC annuity and of social insurance, since they maintain their total amounts of insurance and of saving constant. This is not true anymore at the majority voting equilibrium, since the social insurance rate τ is set at the level most-preferred by the decisive voter, so that the individual choice of a determines simultaneously the saving and total insurance amounts.

There are three different effects of increasing γ on myopics' real utility at the majority voting equilibrium: (i) a direct effect of γ on the amounts of insurance I and of saving S, for a and τ constant, (ii) an indirect effect of γ on I through the variation induced in $\tau_M^V(\gamma)$, and (iii) an indirect effect of γ on I and S through variations in the value of a most-preferred by the agent, $a_M^*(\alpha, \gamma, \tau^V(\alpha_{med}, \gamma))$. The first, direct, effect increases insurance I while decreasing saving S for all individuals, since a larger fraction of the annuity is devoted to insurance. Since myopics over-save and under-insure at equilibrium, this effects increases their real utility. The second effect leads to a lower value of I because, although the identity of the decisive voter is not affected, his most-preferred value of τ decreases with γ. This effect is detrimental to myopics, since they under-insure at equilibrium. The third effect is a priori ambiguous, because the most-preferred value of a, $a^*_M(\alpha, \gamma, \tau^V(\alpha_{med}, \gamma))$, is affected by γ both directly and also indirectly through the variation in τ^V. Whether $a^*_M(\alpha, \gamma, \tau^V(\alpha_{med}, \gamma))$ is increasing or decreasing in γ will depend, among other things, on the individual's degree of myopia α.

Because of these multiple effects, we are unable to determine unambiguously whether myopics benefit or suffer from an increase in γ. We obtain numerically (using Assumption 1) that the real utility of agents who are more myopic than the median ($\alpha < \alpha_{med}$) monotonically decreases with γ while it monotonically increases with γ for agents with $\alpha > \alpha_{med}$.[17] Recall that we have established that the amount of annuity bought at the majority voting equilibrium is increasing in α for $\alpha > \alpha_{med}$: since these individuals buy more annuity, the first, direct effect is large and this may explain why their utility $W^V_M(\alpha, \gamma)$ is increasing with γ. As for very myopic individuals, they tend to buy less annuity, so that a larger fraction of their insurance is financed by income taxation: they then seem to suffer more from the decrease in $\tau^V(\gamma)$ as γ increases.

Although this numerical example is purely suggestive, its has established that

Proposition 3 *Assume that individuals are myopic. Then, (i) $W^V_M(\alpha, \gamma)$ is not in general constant in γ and (ii) the comparative static of $W^V_M(\alpha, \gamma)$ with respect to γ may differ according to the degree of myopia α.*

We now move to the second type of behavioral bias.

6 The optimists

Optimists know the correct average dependency probability in the economy ($\bar{\pi} = \pi$) but under-estimate their own risk both when voting and when buying DLAs. Their (perceived) indirect utility at that stage is given by

$$\begin{aligned} V_O(\alpha, \gamma, \tau) &= u\left(w(1-\tau) - a^*(\alpha, \gamma, \tau, \pi)\right) \\ &\quad + (1-\alpha\pi)\, u\left(R^h(\gamma) a^*_O(\alpha, \gamma, \tau)\right) + \alpha\pi v\left(b(\pi) + R^d(\gamma, \pi) a^*_O(\alpha, \gamma, \tau)\right). \end{aligned}$$

Unlike myopics, they make no mistake when they anticipate the returns from (social and private) insurance and their consumption level when dependent.

[17] The utility of the agent with the median myopia level is of course not affected by γ since he controls both τ^V and $a^*_M(\alpha_{med}, \gamma, \tau^V)$.

We proceed as in the previous section, starting with the analysis of the individually most-preferred bundle of LTC annuity and social insurance, and then studying the majority voting equilibrium.

6.1 The optimal annuity and social insurance choices

Differentiating $V_O(\alpha, \gamma, \tau)$ with respect to τ while making use of the envelope theorem for a, we obtain the FOC

$$\frac{\partial V_O(\alpha, \gamma, \tau)}{\partial \tau} = w\left[\alpha v'(d^d) - u'(c)\right] \leq 0, \tag{18}$$

for any level of γ. Comparing this equation with the FOC for τ of the myopics (equation (11)), we immediately see that optimists put a lower weight on the marginal utility when dependent. It is then clear that they under-weight this state of the world not simply because they under-estimate their own risk (a feature they share with type M agents), but rather because of the discrepancy between what they consider to be their own risk, and the average risk determining the return from the social transfer program. In other words, it is because they consider (public and private) LTC insurance to be actuarially unfair to them that they end up putting a lower weight on the marginal benefit of this transfer. At the same time, optimists do not over-estimate LTC transfers, as myopics do.

Close observation of (18) shows that $\tau_O^*(\alpha, \gamma)$ is zero below some threshold value of α, and then increasing in α. In contrast with myopics, optimists with a very large behavioral bias (i.e., a very low value of α) prefer a zero social insurance contribution rate, because social insurance looks too unfair to them. When α is low enough that $\tau_O^*(\alpha, \gamma)$ is nil, manipulation of (10) shows that $da_O^*(\alpha, \gamma, 0)/d\alpha > 0$: less optimistic agents put more weight on the dependency case where the utility is larger, and hence buy more annuities. Note that, when $\gamma > 0$, optimists then end up with some private insurance, since it is bundled with DLAs.

Whether α is large enough that type O agents most-prefer $\tau_O^*(\alpha, \gamma) > 0$ or not, after tedious but straightforward manipulations of FOCs we obtain the following ranking of marginal utilities:

$$v'(d^d) > u'(c) > u'(d^h),$$

meaning that optimists most-prefer too little consumption when dependent and too much if healthy (compared to the social optimum). This in turn means that they save too much (a necessary condition for d^h to be too large),

$$S_O^*(\alpha, \gamma) = (1-\gamma)a_O^*(\alpha, \gamma, \tau_O^*(\alpha, \gamma)) > S^{opt},$$

and that they prefer too little insurance (since d^d is too low),

$$I_O^*(\alpha, \gamma) = \frac{\tau_O^* (\alpha, \gamma) w + \gamma a_O^* (\alpha, \gamma, \tau_O^* (\alpha, \gamma))}{\pi} < I^{opt}.$$

The intuition for this result runs as follows: optimists want too little insurance, because their optimism induces them both to put too low a weight on the dependency probability, and to consider that insurance (whether public or private) is actuarially unfair to them. Buying too little insurance decreases the marginal cost of saving while increasing its marginal benefit, increasing their most-preferred saving (which is not affected by any apparent actuarial unfairness) amount above S^{opt}. Observe that the only way to save is to buy annuities, so that optimists end up, at their most-preferred allocation, buying too many annuities (compared to a^{opt} defined in (7)) and favoring too little social insurance (compared to τ^{opt} defined in (8)).

Unlike for myopics, we are not in a position to give an explicit formulation for the most-preferred values of τ and a (doing so would require specifying a functional form for the utility functions). This does not prevent us from studying the comparative static analysis of $\tau_O^* (\alpha, \gamma)$ and $a_O^* (\alpha, \gamma, \tau_O^* (\alpha, \gamma))$ with respect to γ and α. Application of the implicit function theorem on (10) and (18) shows that, as γ increases, optimists substitute private to social LTC insurance: $\tau_O^* (\alpha, \gamma)$ decreases with γ while $a_O^* (\alpha, \gamma, \tau_O^* (\alpha, \gamma))$ increases.[18] The intuition for this result is indeed the same as for myopics: optimists have a most-preferred amount of saving S and of (total) insurance I, and these amounts are kept constant as γ increases. Agents then buy more annuities to keep the level of saving constant as γ increases, and react to the additional private insurance bought by decreasing their most-preferred level of social insurance, to keep the total (private plus public) insurance amount constant. This also means that the optimists' correct utility level at their most-preferred bundle,

$$W_O^*(\alpha, \gamma) = W(a_O^* (\alpha, \gamma, \tau_O^* (\alpha, \gamma)) , \tau_O^* (\alpha, \gamma)),$$

is constant with γ .

Application of the implicit function theorem also allows to show, as for myopics, that as α increases optimists substitute public insurance to saving so that total insurance also increases: $da_O^* (\alpha, \gamma, \tau_O^* (\alpha, \gamma)) /d\alpha < 0$ (so that $dS_O^* (\alpha, \gamma) /d\alpha < 0$), $d\tau_O^* (\alpha, \gamma) /d\alpha > 0$ and $dI_O^* (\alpha, \gamma) /d\alpha > 0$. Also, the values of $a_O^* (\alpha, \gamma, \tau_O^* (\alpha, \gamma))$, $\tau_O^* (\alpha, \gamma)$ and $I_O^* (\alpha, \gamma)$ converge to

[18] As we did for myopics, we assume away the cases where the non-negativity constraint on the most-preferred value of τ becomes binding when γ becomes too large.

their socially optimal levels as α tends toward one, so that $W_O^*(\alpha, \gamma)$ increases with α. As α increases, optimists put more weight on the dependency state and consider insurance to be less actuarially unfair. This increases their demand for total insurance, I_O^*. A larger demand for social insurance increases the marginal cost of annuities (since it increases the marginal utility of first-period consumption) while decreasing its benefit (since marginal utility when dependent decreases). This in turn decreases the individual's demand for private savings and thus for annuities. On the other hand, the fact that a less optimistic individual puts more weight on the dependency state leads mechanically to a larger marginal utility from saving, since $v'(d^d) > u'(d^h)$. This latter effect is smaller than the former, leading less optimistic individuals to prefer less saving and LTC annuity as α increases. As is the case for myopics, the increase in total insurance is attained exclusively through an increase in τ_O^*, since the demand for the LTC annuity decreases.

Comparing with the most-preferred allocation of type M agents, we see that the main difference is that myopics equalize marginal utilities when healthy and when young, while optimists have a larger marginal utility when young. Both types of agents end up with too little consumption when dependent. It is not possible to infer from these relationships a comparison of the most-preferred annuity and social insurance amounts of the two types of agents. Indeed, we obtain numerically using Assumption 1 that these comparisons can go both ways depending on the parameters used.

We now proceed to the majority voting equilibrium allocation.

6.2 The majority voting equilibrium

When voting over τ, individual preferences are single-peaked because the SOC holds, so that the median voter is decisive. Since the most-preferred value of τ is (weakly) increasing in α, the decisive voter is the individual with the median value of α. We summarize the results obtained up to now for optimists in the following proposition.

Proposition 4 *When individuals are optimistic and $\gamma < 1$, they buy too much annuity and favor too little social (and total) insurance at their most-preferred allocation (compared to the socially optimal one). Unlike myopics, optimists with very low values of α most-prefer no social insurance at all. Their most-preferred annuity amount then increases with α. Focusing on individuals not too myopic to favor social insurance, we obtain that, as γ increases, they buy more annuities and* *favor less social insurance in order to keep total saving and insurance constant, so that* $W_O^*(\alpha, \gamma)$ *remains constant as well. As they become less optimistic (i.e., as* α *increases), they buy less LTC annuity and favor more (total and) social insurance, increasing* $W_O^*(\alpha, \gamma)$*. The majority chosen value of* τ *corresponds to the one most-preferred by the individual with the median degree of optimism,* α_{med} *:*

$$\tau_O^V(\gamma) = \tau_O^*(\alpha_{med}, \gamma).$$

We now proceed as in the previous section: we study the behavior of the real utility of optimists at the majority voting equilibrium, as defined by

$$W_O^V(\alpha, \gamma) = W(a_O^*\left(\alpha, \gamma, \tau_O^V(\gamma)\right), \tau_O^V(\gamma)),$$

and we answer the same three questions. First, are agents always better off at their individually most-preferred bundle than at the majority voting equilibrium? Second, are less optimistic individuals always better off than more optimistic individuals? Third, what is the value of γ that maximizes the optimists' real utility at the majority voting equilibrium? As for myopics, we focus on the case where $\gamma = 0$ to answer the first two questions.

As for the first question, we can replicate the argument made for myopics to show that $W_O^V(\alpha, 0) > W_O^*(\alpha, 0)$ for agents with $\alpha < \alpha_{med}$, while the opposite holds for individuals with $\alpha > \alpha_{med}$ (in a nutshell, very optimistic individuals benefit from being forced to consume more social insurance than they would wish, while being induced to reduce their over-saving). The only caveat is that this result holds only if $\tau_O^V(0) > 0$: if $\tau_O^V(0) = 0$, we have $W_O^V(\alpha, 0) = W_O^*(\alpha, 0)$ for individuals with $\tau_O^*(\alpha, 0) = 0$, including for sure all who are more optimistic than the median.

We now look at how $W_O^V(\alpha, 0)$ varies with the degree of optimism α. It is easy to show, following a reasoning similar to the one presented in the Appendix, that optimists save too little, given the value of τ, at the majority voting equilibrium. How $W_O^V(\alpha, 0)$ varies when α increases then crucially depends on how agents adapt their saving choice, for $\tau = \tau_O^*(\alpha_{med}, 0)$, as a function of α.

Using the implicit function theorem, we obtain

$$\begin{aligned} \frac{da_O^*(\alpha, \gamma, \tau)}{d\alpha} &\overset{s}{=} \frac{\partial V_O}{\partial a \partial \alpha} \\ &= \pi(v'(d^d) - u'(d^h)) > 0 \end{aligned}$$

as long as $\tau < \tau^{opt}$, which is the case when $\tau = \tau_O^V(0) = \tau_O^*(\alpha_{med}, 0)$. In words, since at the majority-chosen value of τ the social insurance payment is lower than the LTC damage, optimists end up with a larger marginal utility when dependent than when healthy. Since their optimism induces them to put too low a weight on the probability of being dependent when assessing how much to save, they end up saving too little. As being less optimistic moves them closer to the optimal saving amount of non-myopics ($\alpha = 1$) for $\tau = \tau_O^* (\alpha_{med}, 0)$, their correct utility unambiguously increases.

We summarize the latter two results in the following proposition.

Proposition 5 *Assume that individuals are optimistic and offered a pure saving product ($\gamma = 0$). We have that*
(i) $W_O^V(\alpha, 0) \geq W_O^*(\alpha, 0)$ *for individuals with* $\alpha < \alpha_{med}$ *and* $W_O^V(\alpha, 0) \leq W_O^*(\alpha, 0)$ *for individuals with* $\alpha > \alpha_{med}$*, with a strict inequality if* $\tau_O^V(0) > 0$*.*
(ii) $W_O^V(\alpha, 0)$ *is increasing in* α*.*

Moving to the impact of γ on $W_O^V(\alpha, \gamma)$, we obtain analytically the same qualitative effects as those described for myopics. Since we are unable to determine unambiguously the sign of the overall impact of γ, we resort to numerical examples detailed in Assumption 1, and we obtain (as with myopics) that optimists with $\alpha < \alpha_{med}$ reach their highest real utility level for $\gamma = 0$, while the utility of agents with $\alpha > \alpha_{med}$ increases with γ. The main difference with the numerical results obtained for myopics is that $W_O^V(\alpha, \gamma)$ is not monotonically decreasing in γ for individuals with very low values of α, but rather U shaped.

This illustrative example helps us establish the following proposition, which mirrors very closely Proposition 3.

Proposition 6 *Assume that individuals are optimistic. Then, (i)* $W_O^V(\alpha, \gamma)$ *is not in general constant in* γ *and (ii) the comparative static of* $W_O^V(\alpha, \gamma)$ *with respect to* γ *may differ according to the degree of optimism* α*.*

For myopics as well as optimists, we then obtain that the value of γ impacts the utility of agents at the majority voting equilibrium, even though it has no influence on their utility at their most-preferred annuity and social insurance bundle.

We now turn to the last type of behavioral bias.

7 The sophisticated procrastinators

In this section, we assume that, at the time agents vote, they are all sophisticated, anticipating that their future choice of LTC annuity will be made according to their degree of procrastination α. Recall also that procrastinators know the correct average prevalence of dependency in the economy, so that $\bar{\pi} = \pi$. Type S individual's (real and perceived) indirect utility when voting is then

$$\begin{aligned} V_S(\alpha, \gamma, \tau) &= u\left(w(1-\tau) - a_S^*(\alpha, \gamma, \tau)\right) \\ &\quad + (1-\pi)\, u\left(R^h(\gamma) a_S^*(\alpha, \gamma, \tau)\right) + \pi v\left(b(\pi) + R^d(\gamma, \pi) a_S^*(\alpha, \gamma, \tau)\right). \end{aligned}$$

We first determine the individually optimal annuity and social insurance choices of agents, before studying the properties of the majority voting equilibrium.

7.1 The optimal annuity and social insurance choices

The preferred tax rate of a type S individual is denoted by $\tau_S^*(\alpha, \gamma)$ and is such that

$$\begin{aligned} \frac{\partial V_S(\alpha, \gamma, \tau)}{\partial \tau} &= w\left[v'\left(d^d\right) - u'(c)\right] \\ &\quad + \frac{da_S^*(\alpha, \gamma, \tau)}{d\tau}\left[-u'(c) + (1-\pi) R^h u'\left(d^h\right) + \pi R^d v'\left(d^d\right)\right] = 0, \end{aligned}$$

where $da_S^*(\alpha, \gamma, \tau)/d\tau < 0$. The first line represents the direct impact of increasing τ on V_S, while the second line represents the indirect impact through variations of the demand for annuities, $a_S^*(\alpha, \gamma, \tau)$. The second term between brackets represents the impact of increasing the amount of annuities on V_S. It is in general not nil (i.e., we cannot use the envelope theorem) because the utility function that $a_S^*(\alpha, \gamma, \tau)$ maximizes ($U_S^a(\alpha, \gamma, \tau)$) differs from the one that τ maximizes ($V_S(\alpha, \gamma, \tau)$) in the weights used to compute the average second-period utility.

Making use of the FOC for the annuity choice (10) and rearranging terms, we obtain

$$\begin{aligned} \frac{\partial V_S(\alpha, \tau)}{\partial \tau} &= w\left[v'\left(d^d\right) - u'(c)\right] \\ &\quad + \frac{da_S^*(\alpha, \gamma, \tau)}{d\tau}\pi(1-\alpha)\left[R^d v'\left(d^d\right) - R^h u'\left(d^h\right)\right] = 0. \end{aligned} \quad (19)$$

The second term between brackets is the difference between the marginal return of LTC annuities when dependent and when healthy. Recall that S individuals anticipate that they put too little weight on the dependency state (and thus too much on the healthy one) when they decide how much annuity to buy. If the marginal return is higher when dependent, they thus buy too little annuity, which distorts the choice of τ downward because of the substitution between a^* and τ (a lower value of τ increasing the suboptimal amount of $a_S^*(\alpha, \gamma, \tau)$). The reverse holds when the marginal return of the annuity is larger when healthy.

We obtain strikingly different results whether the LTC annuity consists of pure saving ($\gamma = 0$) or also has an insurance component ($0 < \gamma < 1$). When $\gamma = 0$, equation (19) simplifies to

$$\frac{\partial V_S(\alpha, 0, \tau)}{\partial \tau} = \left[v'\left(d^d\right) - u'\left(d^h\right)\right]\left[w(1-\alpha\pi) + \pi(1-\alpha)\frac{da_S^*(\alpha, 0, \tau)}{d\tau}\right] = 0,$$

so that the most-preferred value of τ, $\tau_S^*(\alpha, 0)$, satisfies $v'\left(d^d\right) = u'\left(d^h\right)$.

The intuition for this result runs as follows. With $\gamma = 0$, the insurance transfer received when dependent is exclusively social and determined by τ, while the annuity is indeed pure saving. All S individuals (whatever their degree of procrastination) most-prefer the value of τ that results in a social insurance transfer b equal to the dependency loss L, in order to equalize marginal utilities with or without dependency in the second period. This in turn neutralizes totally the impact of procrastination on the saving choice, because it becomes immaterial that S agents under-weight their utility if dependent when saving, since marginal utility when dependent is equal to marginal utility if in good health. We then have that

$$u'(c) = u'(d^h) = v'(d^d),$$

so that all agents have the same utility (same consumption and same saving) which corresponds to the utility of someone who is not myopic at any time.

When $\gamma > 0$, the LTC annuity contains some insurance element, so it is not possible for S individuals to obtain the socially optimal amount of insurance by setting τ only. Moreover, S individuals with different degrees of procrastination will choose different amounts of annuities, inducing in turn different most-preferred values of τ, and different amounts of saving and of insurance. The unanimity of S individuals in favor of the socially optimal allocation then breaks down as soon as $0 < \gamma < 1$.

We have not been able to obtain further analytical results in that case, and we thus present results based on numerical examples detailed in Assumption 1. We obtain that, for any value of $0 < \gamma < 1$ and of $0 < \alpha < 1$, S agents buy too little annuity and thus save too little (compared to the socially optimal allocation). The anticipation by S individuals that their demand for annuity will be too low has two consequences on their demand for social insurance: first, a low value of a_S^* means that little LTC private insurance is bought as well, so that S individuals should favor a larger value of τ to compensate for this lack of insurance; second, because of the substitutability between annuities and social insurance, a lower value of τ is required to induce their future self to buy more annuities. We obtain that the net impact of these two forces on τ_S^* is positive, with $\tau_S^*(\alpha, \gamma) > \tau^{opt}(\gamma)$ for $0 < \alpha < 1$ and $0 < \gamma < 1$, but that the impact on total insurance can go both ways, with total insurance at the most-preferred allocation larger or smaller than the socially optimum amount L, depending on the values of the parameters γ and α.

This result contrasts starkly with the optimal choices of types M and O. Because they are sophisticated, procrastinators anticipate that they will buy too little annuity and counteract this by favoring more social insurance than would be optimal. Types M and O exhibit the same behavioral bias in both choices, and end up with too much annuity and too little insurance at their most-preferred bundle.

As α increases, S individuals buy more annuity and favor less social insurance, with the most-preferred allocation tending towards the socially optimal one as α gets close to one. The intuition for this result goes as follows. Recall that S agents put too low a weight on the dependency state in their annuity choice. From the observation that they buy too little annuity (from a social viewpoint), we infer that the marginal return of the annuity is larger when dependent than when healthy. As α increases, individuals put more relative weight on the dependency state and thus choose to buy more annuity. This increases the amount of private insurance bought and thus induces a lower preference for τ. We also obtain that this move is beneficial to the individuals: as α increases, the correct utility level of procrastinators agents at their most-preferred allocation,

$$W_S^*(\alpha, \gamma) = W(a_S^*(\alpha, \gamma, \tau_S^*(\alpha, \gamma)), \tau_S^*(\alpha, \gamma)),$$

increases with α.

We now perform a comparative static analysis with respect to γ. As γ increases, the share of the annuity that is devoted to insurance increases. We have seen in sections 5 and 6 that myopics and optimists react to an increase in γ by raising their most-preferred amount of annuity while decreasing τ. We obtain numerically (using Assumption 1) the same comparative static results with S agents, who most-prefer more annuity and less social insurance as γ increases. Also, we obtain numerically that $W_S^*(\alpha, \gamma)$ decreases monotonically with γ. The intuition for this last result is that, as γ increases, it becomes more difficult to disentangle saving from insurance, which prevents S agents from correcting their procrastination.[19] This contrasts with the results obtained with types O and M, who maintain saving and insurance, and thus utility, constant as γ increases.

We summarize these results in the following proposition.

Proposition 7 *When individuals are sophisticated procrastinators,*
(i) and $\gamma = 0$, they unanimously prefer the socially optimal bundle of saving (or annuity) and insurance, as given by (7) and (8);
(ii) and $0 < \gamma < 1$, they are not able to perfectly correct their procrastination by choosing τ, and then differ in their preferences for annuity and social insurance according to their procrastination degree, α. With numerical examples detailed in Assumption 1, we obtain that they buy too little annuity and thus save too little ($a_S^*(\alpha, \gamma, \tau_S^*(\alpha, \gamma)) < a^{opt}(\gamma)$) and prefer too much social insurance ($\tau_S^*(\alpha, \gamma) > \tau^{opt}(\gamma)$), but that their most-preferred amount of total (private plus public) insurance may be lower or larger than the socially optimal level $I^{opt} = L$. As α increases, their demand for annuities increases while their most-preferred value of τ decreases, generating an increase in $W_S^*(\alpha, \gamma)$. As γ increases, the demand for annuity increases while the most-preferred value of τ, and $W_S^*(\alpha, \gamma)$, both decrease.

We now turn to the study of the majority voting equilibrium with S individuals.

7.2 The majority voting equilibrium

Since preferences are single-peaked in τ for $\gamma < 1$, and since $\tau_S^*(\alpha, \gamma)$ is monotone in α with the numerical examples when $0 < \gamma < 1$, we obtain the following proposition.

Proposition 8 *Assume individuals are sophisticated procrastinators.*
(i) When $\gamma = 0$, they unanimously prefer the socially optimal value of τ, $\tau^{opt}(0)$, and all individuals buy the socially optimal amount of annuity/saving, $a^{opt}(0)$.
(ii) When $0 < \gamma < 1$, we obtain with numerical examples based on Assumption 1 that the procrastinator with median value of α is decisive: $\tau_S^V(\gamma) = \tau_S^*(\alpha_{med}, \gamma)$. We also obtain that all individuals buy too little annuity at the majority-voting equilibrium: $a_S^*(\alpha, \gamma, \tau_S^V(\gamma)) < a^{opt}$.

[19] It may seem surprising that $W_S^*(\alpha, \gamma)$ decreases with γ but increases with α, when both α and γ increase a_S^* and decrease τ_S^*. Observe that raising a for γ constant increases saving and moves it closer to its optimal amount S^{opt}, while increasing γ and a has an ambiguous impact on saving.

In the rest of this section, we study the behavior of the correct utility of agents at the majority voting equilibrium,

$$W_S^V(\alpha,\gamma) = W(a_S^*(\alpha,\gamma,\tau_S^V(\gamma)),\tau_S^V(\gamma)),$$

and answer the same three questions as for the other two types of behavioral biases.[20]

The answer to the first question is easy: since, at the time of voting, individuals use their correct utility function and perfectly anticipate their future mistake, we have that $W_S^*(\alpha,\gamma) > W_S^V(\alpha,\gamma)$ for all $0<\gamma<1$ and all $0<\alpha<1$ (except the decisive voter), since they are forced to consume either too little or too much social insurance. This result contrasts sharply with what we have obtained with O and M agents.

As for the second question, we obtain numerically that all individuals buy too little annuity given the value of τ, set at $\tau_S^V(\gamma)$. We also obtain that $W_S^V(\alpha,\gamma)$ increases monotonically with α: as individuals procrastinate less, they increase the amount of annuities purchased, which increases both the amount of saving and of insurance that they enjoy in the second period of their life. This result also stands in sharp contrast with what we obtained for M agents.

Finally, we obtain numerically that $W_S^V(\alpha,\gamma)$ decreases with γ. We have already obtained the same qualitative results with $W_S^*(\alpha,\gamma)$. As γ increases, the biased choice of annuity amount impacts not only saving but also increasingly insurance. This in turn makes it more difficult for S individuals choosing the social insurance amount to counteract their future procrastination. A similar phenomenon is then at play at the majority voting equilibrium, with the caveat that the social insurance amount is determined by the individual with the median procrastination degree.

We summarize these results in the following proposition.

Proposition 9 *Assume that individuals are sophisticated procrastinators. Then,*
(i) $W_S^*(\alpha,0) = W_S^V(\alpha,0) = W^{opt} > W_S^*(\alpha,\gamma) \geq W_S^V(\alpha,\gamma)$ *for all* $\alpha<1$ *and* $\gamma<1$*, with a strict inequality for all* α *except for the decisive voter.*
(ii) With numerical examples detailed in Assumption 1, we have that $W_M^V(\alpha,\gamma)$ *increases with* α *and decreases with* γ*.*

The main message of this section is then that, for S agents, introducing LTC annuities (by increasing γ from $\gamma=0$) is detrimental to all agents, whether utility is measured at their

[20] We focus on $0<\gamma<1$ since $W_S^V(\alpha,0)$ equals the first-best utility level for any α.

most-preferred insurance and saving bundle, or at the majority voting equilibrium.

We now study what happens when individuals only have access to pure insurance on the private market ($\gamma = 1$).

8 Choice of pure insurance ($\gamma = 1$)

When $\gamma = 1$, the annuity product is equivalent to (private) insurance (since $R^h = 0$) and individuals have no access to any saving product. We study the majority voting equilibrium in that case.[21]

Whatever their type of behavioral bias, at the time of buying annuities (i.e., private insurance), all individuals consider public and private insurance as perfect substitutes. The preference for social insurance is then determined by whether agents are sophisticated at the time of voting or not. Sophisticated agents anticipate that they will buy too little annuity. They then unanimously support the value of τ that results in the second-best optimal amount of insurance, I^{SB} (see equation (9)). This in turn drives their demand for private insurance to zero. They attain the second-best optimal utility level–i.e., the maximum utility level attainable given the absence of saving technology.

Myopics and optimists do not anticipate their future mistake at the time of voting. They thus consider social and private insurance as interchangeable. They differ in their most-preferred amount of (total) insurance, with very biased (low α) individuals favoring very little or even no insurance at all. The majority voting equilibrium then implies no social insurance (for any positive value of τ, voters who are not indifferent support a lower value of τ), and individuals prefer to buy insurance on the private market, where they buy too little of it because of their optimism/myopia problem.

We summarize these results in the next proposition.

Proposition 10 *Assume individuals are offered a pure insurance product ($\gamma = 1$).*
(i) If they are sophisticated procrastinators, they unanimously prefer the second-best optimal social insurance amount, and no private insurance.
(ii) If they are myopic or optimistic, they vote for no social insurance and all buy too little insurance on the private market.

[21]We aim at keeping this section short, because the absence of any saving technology makes it less relevant. A more complete analytical version is available upon request.

We conclude by taking stock of our main results and of how they shed light on stylized facts and inform policy recommendations.

9 Conclusion

We have started this paper with the observation that individuals are insufficiently covered by (social and private) insurance to face their LTC risks. Several authors and organizations, including the OECD, mention behavioral biases as a potential source for this low demand. What light do our results shed on this explanation?

We obtain a lower-than-optimal demand for insurance at the majority voting equilibrium when agents are either myopic or optimistic, but not when they are sophisticated procrastinators. All myopics and optimists favor too little social LTC insurance (so that the amount chosen at the majority is also sub-optimal), but for different reasons: type M because they over-estimate the insurance transfer received in case of dependency, type O because they consider insurance to be actuarially unfair to them. The amount of annuity chosen when social insurance is set at its majority-chosen level is too small, given this contribution rate. The reason is that both types M and O put too little weight on the dependency state, where marginal utility is larger than if healthy because of the low level of social insurance. Both types then end up with too little social and private insurance, and also too little saving.

The actions of sophisticated procrastinators do not fit the stylized fact. Because they are sophisticated, procrastinators anticipate that they will buy too little annuity and counteract this by favoring more social insurance when voting. If offered a pure saving product, they are able to perfectly correct their procrastination and end up with the socially optimal amounts of insurance and saving. If offered a DLA with a higher return when dependent, it becomes more difficult to disentangle saving from insurance, which prevents S individuals from perfectly correcting their procrastination. In stark contrast with the O and M agents, they prefer too little DLA and too much social insurance at their most-preferred bundle. None of these two cases fits the stylized fact.

What policy recommendations can we draw from our analysis? Since the behavioral problem at stake seems to be misperception of risk (rather than procrastination), it is tempting to recommend information campaigns with the aim of helping individuals to better assess their risk (and the average risk) of becoming dependent. Our results call for caution: with very myopic individuals, we have seen that decreasing their degree of myopia may result in them favoring less DLA, and ending up worse off than more myopic individuals![22] We do not obtain this type of counter-intuitive results with optimists. This then calls for additional empirical research, in order to better assess the distribution of behavioral biases in the population, and whether individuals correctly estimate average risks (and thus the returns from social and private insurance) or not.

What light do we shed on the desirability of this new instrument, the LTC annuity or DLA? The picture here is quite bleak. First, observe that offering this type of annuity does not solve the behavioral bias problem. More precisely, the most-preferred allocation of both myopics and optimists is not affected by the characteristics of the DLA, since agents change their favored amount of DLA and of social insurance to keep the amount of saving and of (total) insurance constant. The picture gets more complex when we look at the utility level reached at the majority voting equilibrium, since we obtain (numerically) that the utility of very biased M and O agents tends to decrease when the DLA offers more contrasted returns according to the dependency status, with the opposite holding for less biased individuals. Since less biased individuals are often better off than more biased agents (with the caveat mentioned above for very myopic individuals), introducing DLAs runs the risk of increasing the inequality between individuals. Finally, sophisticated procrastinators are harmed by the introduction of DLAs, which, by mixing saving and insurance, prevents them from perfectly correcting their procrastination when voting.

We end with two observations. First, we have seen that the empirical evidence on behavioral biases points to the possibility that some individuals actually over-estimate their dependency risk. How would that change our results? The result that the majority-chosen level of social insurance is too low with myopics and optimists, and too large with sophisticated procrastinators, holds as long as a majority of individuals under-estimate their risk. At the majority voting equilibrium, agents with $\alpha > 1$ demand more annuity (and thus saving) than is socially optimal given the amount of social insurance. While this does not fit the general picture, there is no denying that some individuals could exhibit such a pattern. Additional empirical (or experimental) evidence would be needed to assess the link between behavioral bias and the choice of financial assets to finance LTC.

[22]This comparative static result for an agent with a low value of α holds as long as the information campaign does not increase the value of α_{med}.

Finally, we acknowledge that we have treated the distribution of behavioral biases as a "black box". Further research is needed in order to, first, to endogenize this distribution and to make the link with public policies and, second, to study its evolution over time, in the spirit of Aldashev and Baland (2012) for instance.

10 Appendix

Observe first that, at $\tau = \tau_M^V(0)$, we have that $b = \alpha_{med} L$ while $\tilde{b} = (\alpha_{med}/\alpha)L$. We then have that $d^d - L < d^h$ (so that $v'(d^d) > u'(d^h)$) and $\tilde{d}^d > d^d$. We have that

$$\frac{\partial W_M^V(\alpha, 0)}{\partial a} = -u'(c) + (1-\pi)u'\left(d^h\right) + \pi v'\left(d^d\right).$$

Making use of the FOC for $a_M^*(\alpha, \gamma, \tau)$,

$$-u'(c) + (1-\alpha\pi)u'\left(d^h\right) + \alpha\pi v'\left(\tilde{d}^d\right) = 0,$$

we obtain

$$\begin{aligned} \frac{\partial W_M^V(\alpha, 0)}{\partial a}\Big|_{a=a_M^*(\alpha,\gamma,\tau)} &= -(1-\alpha\pi)u'\left(d^h\right) - \alpha\pi v'\left(\tilde{d}^d\right) + (1-\pi)u'\left(d^h\right) + \pi v'\left(d^d\right) \\ &= \pi\left[v'\left(d^d\right) - \left((1-\alpha)u'\left(d^h\right) + \alpha v'\left(\tilde{d}^d\right)\right)\right] > 0. \end{aligned}$$

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