Optimal Prevention when Coexistence Matters*

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Abstract

We study the optimal subsidy on prevention against premature death in an economy composed of two-person households, where the survival of the spouse matters, either because of self-oriented coexistence concerns, or because of altruism. Under a non-cooperative household model, the laissez-faire prevention levels are shown to be lower than the first-best levels, to an extent that is increasing in self-oriented coexistence concerns and decreasing in spousal altruism. The decentralization of the social optimum requires thus a subsidy on prevention depending on the precise type of coexistence concerns. Our results are shown to be globally robust to the introduction of imperfect observability of preferences, life insurance, imperfect marriage matching and myopia. We conclude by studying the optimal prevention in a cooperative household model with unequal bargaining power.

Keywords: mortality, coexistence, non-cooperative household models, optimal taxation, prevention, old-age dependency.

JEL codes: H51, I12, I18.

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1 Introduction

As this is now largely acknowledged, individuals can, through their lifestyle, influence their life expectancy to a significant extent.[1] For instance, Balia and Jones (2008), in their study on premature mortality in Great Britain, find, while correcting for biases due to endogeneity and unobserved heterogeneity, that lifestyles predict about 25 percents of the overall inequality in mortality, with strong contributions of non smoking and sleep patterns.[2]

The large empirical evidence supporting a significant impact of individuals on their life expectancy raises the issue of the optimal fiscal treatment of prevention. In a pioneer article, Besley (1989) argues that health-related choices are subject to various behavioral imperfections: agents tend to misperceive the survival process, and adopt suboptimal behaviors, which they will regret later on in their life. This supports governmental intervention aimed at inducing the optimal health-related behaviors. More recently, Leroux *et al* (2011a, 2011b) study the optimal subsidy on prevention when agents differ in three characteristics affecting survival prospects: genetic background, myopia and productivity.

Those studies on the optimal prevention are all based on models where individuals care only about their *own* survival, but not about the survival of others. Although analytically convenient, that assumption simplifies the problem significantly. In real life, individuals care a lot about the survival of others, such as their spouse, children, parents and friends. Blanchflower and Oswald (2004) showed that an amount of not less than \$100,000 per annum would be necessary to compensate the fact of being widowed. Thus coexistence matters a lot.

The goal of this paper is to reexamine the design of the optimal prevention policy in an economy where individuals care not only about their own survival, but also about the survival of others. For that purpose, two particular issues must be studied. First, given that how a person "cares" about the survival of others may matter a lot for the optimal policy design, one needs to examine the structure of individual preferences. Second, the precise way in which decisions are made within the household matters also for the optimal policy.

Coexistence concerns can be of two kinds. On the one hand, a person can exhibit a *self-oriented* concern for coexistence with the spouse. In that case, the person would like his wife or her husband to survive, to enjoy the coexistence with her or his, who is treated as a good to be consumed. On the other hand, a person can exhibit an *altruistic* concern for his / her spouse. In that case, the person cares about the total well-being of the spouse, and his / her survival is valued only insofar as this raises the well-being of his / her spouse.

Empirical studies support the existence of large coexistence concerns, but have not, so far, distinguished between self-oriented and altruistic coexistence concerns.[3] However, the two kinds of concerns are far from equivalent regard-

[1] See, among others, the studies by Kaplan *et al* (1987), Mullahy and Portney (1990), Mullahy and Sindelar (1996), and Contoyannis and Jones (2004).

[2] Balia and Jones (2008) focused on six aspects of lifestyles: smoking, drinking, regular breakfast, sleep patterns, excessive eating and sporting activities.

[3] The necessity of a large monetary compensation in case of widowhood or widowerhood does not reveal anything about the *reasons* behind coexistence concerns.

ing the existence of *externalities*. Under self-oriented coexistence concerns, a person does not take his / her spouse's coexistence concerns into account when choosing how much to invest in prevention, so that externalities arise. If, on the contrary, coexistence concerns are driven by (im)perfect altruism, agents do (partly) internalize the effects of prevention on the spouse's welfare. Hence, whether prevention behaviors give rise to externalities or not depends on the form of coexistence concerns: self-oriented or altruistic.

The distinction between different ways to "care" about coexistence can be illustrated by the example of sin goods consumption, i.e. the opposite of preventive behavior. A smoker may well take into account the negative effect of smoking on the duration of coexistence with his family (through the reduction of his life expectancy, and, in case of passive smoking, through the reduction of others' survival chances), but may, in the absence of altruism, ignore the emotional suffering his family will feel from his early death. Self-oriented coexistence concerns are thus a source of externalities, unlike altruistic concerns.

Besides the distinction between self-oriented and altruistic coexistence concerns, another central issue for the design of optimal policy concerns how prevention decisions are made within the couple. Two kinds of household decision models exist: the non-cooperative model and the cooperative model. In the former, prevention is chosen by each spouse in such a way as to maximize one's own welfare, subject to one's own budget constraint. In the latter, prevention is chosen in such a way as to maximize the household collective welfare, subject to the household budget constraint.

Non-cooperative models seem to be a natural baseline, whatever the group of humans considered is, including the family or the couple. After all, coexistence concerns - egoistic or altruistic - do not imply cooperation, but may lead to various strategic behaviors.[4] A collective choice on individual prevention behaviors does not seem more plausible than a collective choice on individual consumptions. However, the cooperative household model is also defendable, since cooperation is easier to achieve in a couple than in other groups. In particular, the marriage institution, by allowing the use of divorce as a threat, can serve as a commitment device, which forces spouses to act cooperatively (see Cigno 2012). We will thus consider those two classes of household models successively. Nonetheless, we will pay more attention to the non-cooperative model, because a large part of prevention can hardly be monitored at the household level, so that the marriage constitutes, in that context, a quite imperfect commitment device. Hence the non-cooperative framework will be taken here as the baseline model.

The present paper proposes thus to examine the fiscal treatment of prevention when agents have two kinds of coexistence concerns - self-oriented or altruistic -, and when prevention decisions take place either in a non-cooperative environment, or, alternatively, in a cooperative environment. For that purpose, we consider a two-period economy, where the population is composed of two-person households, and where each individual faces risk about his own longevity and

[4] This observation is quite common in public economics. Children concerned with the health (or with the welfare) of their dependent parents can play various strategies to benefit from healthy (or happy) parents without having to serve as a caregiver (see Jousten *et al.* 2005).

about the one of his spouse. Households are heterogeneous in the preferences of the spouses, i.e. various degrees of self-oriented coexistence concerns and of altruistic concerns, but the matching between spouses is perfect.

Prevention takes here the form of a preventive expenditure made at the young age, which raises the probability of survival to the old-age. Moreover, to reflect the observed deterioration of the health status due to ageing, it is assumed that an elderly person enjoys autonomy with some probability, but suffers from old-age dependency otherwise.[5] Old-age dependency matters in our context, because the health status of the spouse is a major determinant of the welfare gains associated with coexistence (see Braackmann 2009).

Anticipating on our results, we show that, in a non-cooperative household, preventive expenditures chosen at the laissez-faire are smaller than the socially optimal ones, to an extent that is increasing in the intensity of self-oriented coexistence concerns, and decreasing in the degree of spousal pure altruism. Hence, the decentralization of the first-best optimum requires a Pigouvian subsidy on prevention, which depends on the precise form of coexistence concerns. Moreover, under unobservable preferences, incentive compatibility constraints reinforce the need to subsidize prevention for agents with high coexistence gains. Those results are shown to be robust to the introduction of life insurance, imperfect sorting on the marriage market, and myopia. Turning then to the cooperative household model, we show that some public intervention is still justified, even under perfect information, in order to correct for an insufficient prevention due to an unequal division of bargaining power within the household.

By its results, this study first complements health economics papers on optimal prevention under endogenous longevity, but without coexistence concerns.[6] Secondly, we add to the literature on non-cooperative family decision-making, which examined various issues, but not optimal prevention.[7] Thirdly, we complement also long-term care (LTC) studies on the optimal policy when children differ in altruism towards parents.[8] Finally, this paper can also be related to the literature on the tax treatment of couples, which did not consider survival.[9]

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 characterizes the laissez-faire. Section 4 derives the utilitarian social optimum, and studies its decentralization. Section 5 focuses on the second-best problem, where individual preferences cannot be observed by the social planner. Section 6 explores the robustness of our results to the introduction of (i) endogenous probabilities of old-age autonomy, (ii) life insurance, (iii) imperfect mariage matching, (iv) individual myopia. Section 7 compares our results with the ones under a cooperative household model. Section 8 concludes.

[5] Dependency consists of difficulties to carry out daily activities (washing, eating, etc.)

[6] See, among others, Leroux and Ponthiere (2009), Leroux *et al* (2011a, 2011b).

[7] Following contributions of Becker (1974), Ulph (1988), Konrad and Lommerud (1995), and Chen and Wooley (2001), non-cooperative models were applied to various family issues, such as the division of housework (Bragstad, 1989), domestic violence (Taucher *et al*, 1991) expenditures on children (Del Boca and Flinn, 1994), and savings (Browning, 2000).

[8] See Jousten *et al* (2005) and Pestieau and Sato (2008).

[9] See Apps and Rees (1988, 1999, 2007), Boskin and Sheshinski (1983), Cremer *et al.* (2007) and Kleven *et al.* (2006).

2 The non-cooperative model

2.1 Environment

We consider a population of individuals who are grouped in couples, composed of one man and one woman.[10] Agents live a first period with certainty, and enjoy a second period with a probability π.[11] Surviving agents are autonomous with a probability p, and suffer from old-age dependency with a probability $1-p$.

Individuals are heterogeneous in three characteristics:[12]

- The gender: men, indexed by M, and women, indexed by F.
- The altruism towards the spouse, denoted by α^k. We assume two degrees of altruism $k \in \{A, a\}$: $\alpha^A > \alpha^a \geq 0$.
- The self-oriented concern for coexistence with the spouse, denoted by Φ_i^j. We assume two degrees of concerns $j \in \{C, c\}$: $\Phi_i^C > \Phi_i^c \geq 0$.

2.2 Demography and health

When young, agents invest in prevention against premature death, which raises their probability of survival to the old age. For that purpose, an agent of gender $i \in \{M, F\}$, with a degree of altruism $k \in \{A, a\}$ and with a degree of self-oriented coexistence concern $j \in \{C, c\}$ invests an amount h_i^{kj} in prevention.

An agent of gender $i \in \{M, F\}$ investing h_i^{kj} in his or her health will survive to the second period with a probability:

$$\pi_i = \pi_i \left(h_i^{kj} \right) \tag{1}$$

where we assume, as usual, $\pi_i'(\cdot) > 0$ and $\pi_i''(\cdot) < 0$ and $0 < \pi_i(\cdot) < 1$. Following the demographic literature on women's physiological advantage (see Vallin 2002), we assume that the survival function takes a gender-specific form:

$$\pi_F \left(\bar{h} \right) = \pi \left(\bar{h} \right) > \pi_M \left(\bar{h} \right) = \varepsilon \pi \left(\bar{h} \right) \tag{2}$$

with $\varepsilon < 1$, i.e. women have a higher life expectancy than men for an *equal* investment in their health $\bar{h}$.

We denote by p_i the (exogenous) probability of being autonomous at the old age, whereas $1-p_i$ is the probability of old-age dependency, for $i \in \{M, F\}$.[13] Women's physiological advantage implies, *ceteris paribus*, a higher chance of being autonomous at the old age (Cambois *et al* 2008), so that $p_F \geq p_M$.

Given that agents care not only about their own survival and health, but, also, about the survival and health of their spouse, the number of possible scenarios of life, equal to 3 in a model without coexistence concerns (i.e. healthy survival, unhealthy survival, premature death) is here raised to $3^2 = 9$ scenarios. To illustrate this, Figure 1 shows the lottery of life faced by a man.

[10] Note that relaxing that assumption would not affect our results.

[11] The length of a period is normalized to 1.

[12] In order to focus on coexistence concerns, we assume that there is no other source of heterogeneity. This implies, among other things, equal resources w for all agents.

[13] See Section 6 for an extension with endogenous probabilities of autonomy.

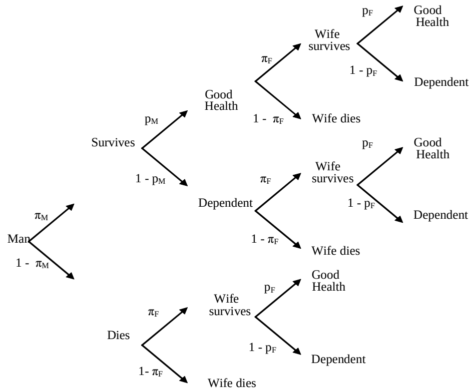

Figure 1: Man's lotery under coexistence concerns

2.3 Individual preferences

Individual preferences over lotteries of life are assumed to satisfy the expected utility hypothesis.[14] When specifying the welfare associated to each scenario of the lottery of life, we assume that lifetime welfare takes a standard time-additive form, where temporal utility is state-dependent.[15] The function $u(\cdot)$ denotes the temporal utility of consumption under autonomy, whereas the function $v(\cdot) = u(\cdot) - L$ denotes the utility of consumption under dependency, L being a utility loss due to dependency. As usual, we set $u'(\cdot) > 0$, $u''(\cdot) < 0$.

Regarding coexistence concerns, there exist two ways in which agents "care" about the survival of others. First, a spouse has a *self-oriented* or egoistic concern for coexistence, in the sense that the husband, for instance, would like his wife to survive and be healthy *if* he survives, but this has nothing to do with the welfare of his wife. In sum, partners care about the survival and health of their spouse to avoid loneliness.[16] Second, an agent cares also about what his or her partner feels, that is about her *welfare*. That form of concern is usually referred to as "pure" altruism. The altruistic interest of the agent in his / her partner is not conditional on his / her own survival, contrary to what prevailed under the first motive. Those two coexistence concerns will be formalized as follows.

Regarding self-oriented coexistence concerns, we assume that coexistence with the spouse enters temporal welfare in an additive form, which depends on the health status of the spouse. Denoting by $\gamma^j > 0$ the welfare gain enjoyed by an agent with self-oriented coexistence concern $j \in \{C, c\}$ when he coexists with an autonomous spouse, and denoting by $\chi\gamma^j$ the welfare gain enjoyed when coexisting with a dependent spouse, the expected welfare gain for an agent of

[14] This is an obvious simplification. See Leroux and Ponthiere (2009) for optimal prevention when agents are not expected utility maximizers.

[15] As usual, the utility of death is normalized to zero.

[16] We exclude the possibility that agents could remarry after the death of a spouse. This would complicate our analysis without providing more insights for the issue at stake.

gender i and type $j \in \{C, c\}$ from the survival of his spouse of gender ℓ is:

$$\Phi_i^j = \gamma^j \left[p_\ell + \chi \left(1 - p_\ell\right)\right]$$

We refer to this as the "self-oriented coexistence benefits". As one prefers coexistence with an autonomous spouse, we have $0 < \chi < 1$. Moreover, as $\gamma^C > \gamma^c$, we have $\Phi_i^C \geq \Phi_i^c \; \forall i$. Furthermore, since $p_F \geq p_M$, we have $\Phi_M^j \geq \Phi_F^j \; \forall j$.

As far as altruism is concerned, we assume that altruistic concerns enter the utility function in a standard additive way. For the sake of simplicity, altruism concerns uniquely the "private" (i.e. non altruistic) part of the spouse's welfare. The degree of altruism of an agent of type $k \in \{A, a\}$ is captured by the parameter $0 \leq \alpha^k \leq 1$, which equals the extent to which that agent is sensitive to his / her spouse's "private" welfare.

The preferences of an agent of gender i with type (k, j) living with a spouse of gender ℓ of type kj can, after simplifications, be represented by:

$$V_i^{kj}\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right)\Big|_{\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)} = \begin{array}{l} U_i\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right) + \pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_i^j \\ +\alpha^k\left[U_\ell\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right) + \pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_\ell^j\right] \end{array} \tag{3}$$

where $V_i^{kj}(\cdot)$ is the utility of an agent of gender i with a type (k, j) given the allocation of his spouse, $\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)$. $V_i^{kj}(\cdot)$ is a function of the three control variables of the agent: his first- and second-period consumptions c_i^{kj} and d_i^{kj}, as well as his prevention h_i^{kj}. $U_i(\cdot)$ denotes the expected lifetime welfare in the absence of coexistence concerns. It is defined as:

$$U_i\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right) = u\left(c_i^{kj}\right) + \pi_i\left(h_i^{kj}\right)\left[u\left(d_i^{kj}\right) - \left(1 - p_i\right)L\right]$$

In (3), the expected lifetime welfare of the agent is the sum of three terms. The first term is the expected utility of the agent without coexistence concerns. The second term is the expected welfare gain from coexisting with his spouse. The last term reflects altruism: the agent cares about the welfare of his spouse. The last two terms depend on the spouses' *joint life expectancy*, i.e. $1 + \pi_i(\cdot)\pi_\ell(\cdot)$.[17]

2.4 Households

Regarding the composition of households, we assume, for the sake of analytical tractability, a perfect sorting on the marriage market, i.e. the couple formation process is such that agents with some degree of self-oriented coexistence concerns and altruism form couples with agents having the *same* degree of selfish coexistence concerns and altruism.[18] This yields four types of (k, j)-couples, depending on α^k and γ^j: types (a, c), (a, C), (A, c) and (A, C).

[17] The joint life expectancy is the average period of coexistence for two persons, conditionally on independent individual vectors of age-specific probabilities of death (see Ponthiere 2007).

[18] Such a perfect sorting could be achieved, for instance, by allowing divorce and remarriage as long as the perfect match has not be found. We relax that assumption in Section 6.

As far as the behavior of the household is concerned, we assume that agents, although being in a couple, act in a *non-cooperative* manner.[19] This approach to agents' decisions is probably a stronger assumption inside couples than outside couples, since one can expect cooperation within couples.[20] However, in our context, agents affect their survival prospects through individual prevention, which is quite difficult to monitor at the household level. This is why we take the non-cooperative model as a baseline setting.[21]

3 The laissez-faire

We focus here on the standard concept of Cournot-Nash equilibrium. This equilibrium is defined here as a pair of individual strategies $\left((c_M^{kj}, d_M^{kj}, h_M^{kj}), (c_F^{kj}, d_F^{kj}, h_F^{kj})\right)$, where c_M^{kj}, d_M^{kj} and h_M^{kj} are the optimal levels of consumption and prevention for men given that $(c_F^{kj}, d_F^{kj}, h_F^{kj})$ prevails for women, whereas c_F^{kj}, d_F^{kj} and h_F^{kj} are the optimal consumptions and prevention for women given that $(c_M^{kj}, d_M^{kj}, h_M^{kj})$ prevails for men. At the Cournot-Nash equilibrium, each agent maximizes his utility given his anticipations on the other's decision, and those anticipations are verified. Thus, no agent would like to change his behavior, even after having discovered what the other agent chooses.

Let us now characterize that equilibrium. We assume that individual savings s_i are invested in a perfect annuity market yielding actuarially fair returns (for different risk classes), so that the gross return on annuitized savings, denoted by $\tilde{R}_i^{kj}$, equals $R_i^{kj}/\pi_i\left(h_i^{kj}\right)$, where R_i^{kj} is equal to 1 plus the interest rate. For simplicity, we suppose that $R_i^{kj} = 1$ (zero interest rate), and that agents perfectly anticipate the impact of prevention on the return of annuitized savings.[22]

The problem of an agent of gender i living with an agent of gender ℓ in a (k, j) couple can be written as:

$$\max_{c_i^{kj}, d_i^{kj}, h_i^{kj}} V_i^{kj}\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right)\Big|_{\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)} \quad \text{s.to} \left\{ \begin{array}{l} c_i^{kj} \leq w - h_i^{kj} - s_i^{kj} \\ d_i^{kj} \leq \tilde{R}_i^{kj} s_i^{kj} \end{array} \right.$$

Rearranging first-order conditions yields

$$u'\left(c_i^{kj}\right) = u'\left(d_i^{kj}\right) \tag{4}$$

$$\pi_i'\left(h_i^{kj}\right)\left[\begin{array}{l} u\left(d_i^{kj}\right) - d_i^{kj} u'\left(d_i^{kj}\right) - (1 - p_i) L \\ +\pi_\ell\left(h_\ell^{kj}\right)\left[\Phi_i^j + \alpha^k \Phi_\ell^j\right] \end{array}\right] = u'\left(d_i^{kj}\right) \tag{5}$$

[19] As mentionned in D'Aspremont and Dos Santos Ferreira (2009), a non-cooperative couple is "an independant management system in which each spouse keeps his/her own income separate and has responsability for different items of household expenditure".

[20] Note that the form of the legislation may also affect how spouses behave within the couple (see Cigno 1991). Here we abstract from those legal aspects.

[21] We will relax this assumption in Section 7 and see how it changes our results.

[22] Another approach consists in assuming that agent do not internalize the impact of h_i^{kj} on the annuity return (see Becker and Philipson, 1998).

Consumptions are smoothed across periods.[23] The equilibrium condition for prevention equalizes the direct marginal welfare loss of increasing prevention (the RHS), with marginal benefits (the LHS). These benefits are equal to the marginal increase in utility due to a higher survival chance $\pi_i'\left(h_i^{kj}\right)u\left(d_i^{kj}\right)$, net of the decrease in the return of annuities, $\pi_i'\left(h_i^{kj}\right)d_i^{kj}u'\left(d_i^{kj}\right)$. The term $\pi_i'\left(h_i^{kj}\right)(1-p_i)L$ accounts for the additional cost related to dependency, as increasing survival chances also increases the chance to be disabled.

In addition, prevention depends on the welfare gains that agents obtain from coexisting with their spouse. This is represented by the last term on the LHS $\pi_i'\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\left[\Phi_i^j+\alpha^k\Phi_\ell^j\right]$. The first term inside brackets is related to the gain the agent gets from coexisting with his spouse, while the second term is related to the fact that he partly internalizes the welfare gains he creates on his spouse by investing in prevention. The higher the selfish concerns (i.e. the higher Φ_i^j) and /or the higher the altruistic concern is (i.e. the higher α^k), the higher h_i^{kj} is *ceteris paribus*. Note also that the agent's prevention h_i^{kj} is increasing in the level of the spouse's prevention h_ℓ^{kj} (through the survival probability of the spouse, $\pi_\ell(\cdot)$), whatever the concern for coexistence is egoistic and / or altruistic.

At a Cournot-Nash equilibrium, a man and a women in a couple of type (k,j) choose consumptions and preventions bundles, respectively $(c_M^{kj},d_M^{kj},h_M^{kj})$ and $(c_F^{kj},d_F^{kj},h_F^{kj})$, in such a way that conditions (4) and (5) are satisfied both for the two spouses. It should be stressed that, in general, nothing insures the existence of a Cournot-Nash equilibrium in our economy, that is, the existence of a pair of strategies $\left((c_M^{kj},d_M^{kj},h_M^{kj}),(c_F^{kj},d_F^{kj},h_F^{kj})\right)$ such that conditions (4) to (5) are satisfied for each spouse. The uniqueness and stability of the equilibrium are not guaranteed either. Additional assumptions on preferences and on the survival functions would be necessary to investigate those issues further.

We assume, in the rest of the paper, that a unique stable Cournot-Nash equilibrium exists. Under that assumption, conditions (4) to (5) can be used to characterize the laissez-faire allocation in our economy.

Proposition 1 *Assume that a unique pair of strategies* $\left((c_M^{kj},d_M^{kj},h_M^{kj}),(c_F^{kj},d_F^{kj},h_F^{kj})\right)$ *satisfies conditions (4) and (5) for each spouse. Then the laissez-faire allocation is such that, for any couple with type* (k,j)*:*
- $c_M^{kj}=d_M^{kj}$ *and* $c_F^{kj}=d_F^{kj}$, $\forall j\in\{C,c\}$, $\forall k\in\{A,a\}$;
- h_i^{kj} *is increasing in* α^k, Φ_F^j *and* Φ_M^j.

Proof. The equalization of consumptions follows from the FOCs for optimal consumptions. Regarding the level of prevention, the LHS of the FOC for optimal prevention is, under our assumptions on coexistence benefits, increasing in α^k. Hence, a higher α^k must, for an equal RHS, lead to a fall of $\pi_i'\left(h_i^{kj}\right)$. This can only be achieved for a higher level of prevention h_i^{kj}. The same rationale holds for the influence of self-oriented coexistence gains Φ_F^j and Φ_M^j. ■

[23] This is a direct consequence of our assumptions on preferences and on the annuity market.

Note also that the laissez-faire levels of prevention depend on the probabilities of old-age dependency p_M and p_F, through their impact on coexistence gains Φ_F^j and Φ_M^j. The more healthy the old age is expected to be, the more one will invest in prevention against premature death. Here again, the form of coexistence concerns determines the precise form of the influence of old-age dependency on prevention. Under purely self-oriented concerns, the prevention level depends only on the agent's own risk of old-age dependency. On the contrary, once some altruism exists, the individual investment in prevention becomes increasing with the probability that the spouse is autonomous at the old age.

We can also use the above equilibrium conditions to compare the laissez-faire allocations of men and women belonging to a given couple of type-(j,k).

Proposition 2 *At the laissez-faire allocation, we have, inside a given couple (k,j), either $d_F^{kj} > d_M^{kj}$ and $h_F^{kj} < h_M^{kj}$ or $d_F^{kj} < d_M^{kj}$ and $h_F^{kj} \gtrless h_M^{kj}$.*

Proof. See the Appendix. ■

It is not obvious to see whether men invest more or less in prevention than women. To see this, let us consider equation (5) for two spouses F and M, assuming that $d_F^{kj} = d_M^{kj}$. Men have a lower probability of survival and autonomy than women, yielding a lower return from prevention. But men obtain from and create on their wife positive welfare benefits, which are higher than the ones created and obtained by their wives, that is, $\pi_M\left(\bar{h}\right)\left[\Phi_F^j + \alpha^k \Phi_M^j\right] < \pi_F\left(\bar{h}\right)\left[\Phi_M^j + \alpha^k \Phi_F^j\right]$ as $\Phi_M^j > \Phi_F^j$. Depending on which effect dominates, we have $h_F^{kj} \gtrless h_M^{kj}$.[24]

4 The social optimum

In this section, we use, as the social objective, the standard utilitarian social welfare function, which we regard here as a benchmark social objective.[25] Note that, in our context, it is not straightforward to see how altruistic concerns should be taken into account by the social planner.[26]

First, one can consider that the social welfare function should rely on the *actual* altruistic coefficients, i.e. α^k, whatever $k = \{A, a\}$ is. Second, one could assume that the social planner should *not* take altruistic concerns into account, and should fix all altruistic coefficients α^k to zero, on the grounds that altruistic preferences should be regarded as irrelevant for the distribution of income (see Hammond 1987). A third position consists in claiming that altruistic concerns should be taken into account by the social planner, not in their existing forms, but, rather, under *an ideal form*, i.e. $\bar{\alpha}$ should be fixed to 1. The planner should thus do *as if* couples were "ideal" couples, in which each member would be able to fully internalize the impact of his actions on the welfare of his spouse.

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[24] This is reinforced by the fact, that, in equilibrium, consumptions differ across gender.

[25] As this is well-known, the aggregation of utilities of agents with different preferences makes sense only if individual utilities are interpersonally comparable. One way to achieve this is, as proposed by Mirrlees (1982, p. 78-80), by means of discussions between agents about utilities. In the rest of this paper, we assume that agents can communicate about their life experiences, and reach an agreement as to how their welfare should be included in the social welfare function.

[26] On this, see Jousten *et al* (2005).

In this section, we will not adhere to the first position, as it is unfair to make the social optimum dependent on actual altruism. On the contrary, we will impose $\alpha^k = \bar{\alpha}$ in the planner's objective function. That solution encompasses the second and third positions, with, respectively, $\bar{\alpha} = 0$ and $\bar{\alpha} = 1$.

4.1 Centralized solution

The problem of the utilitarian social planner can be written as:

$$\max_{c_i^{kj}, d_i^{kj}, h_i^{kj}} \sum_k \sum_j n^{k,j} \sum_i V_i^{kj}\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right)\Big|_{\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)}$$

$$\text{s.to} \sum_k \sum_j n^{kj}\left[w - \sum_i c_i^{kj} + h_i^{kj} + \pi_i\left(h_i^{kj}\right) d_i^{kj}\right] \geq 0 \qquad \text{(A)}$$

where $n^{k,j}$ is the number of couples with pure altruism α^k and coexistence benefit Φ_i^j. In the Appendix, we show that the optimal allocation satisfies:

$$c_M^{kj} = c_F^{kj} = d_M^{kj} = d_F^{kj} = \bar{c} \qquad (6)$$

$$\pi_M{}'\left(h_M^{kj}\right)\left[\begin{array}{r} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1-p_M)L \\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array}\right] = \frac{\lambda}{(1+\bar{\alpha})} \qquad (7)$$

$$\pi_F{}'\left(h_F^{kj}\right)\left[\begin{array}{r} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1-p_F)L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array}\right] = \frac{\lambda}{(1+\bar{\alpha})} \qquad (8)$$

Consumptions should thus be equalized across agents and periods. However, prevention is influenced both by the gender, through (π_i, p_i), and by the type of couple j through Φ_i^j, but not on α^k as the social planner takes $\bar{\alpha}$ for every agents. Let us study the reasons for this differentiation.

For that purpose, let us first focus on the differences between h_F^{kj} and h_M^{kj}, assuming that men and women are from the same couple's type $j = \{C, c\}$. In that case, we do not know whether $h_F^{kj} \lesseqgtr h_M^{kj}$, as two countervailing effects are at work. On the one hand, men have lower probabilities of survival and autonomy, which pushes toward less prevention for men. On the other hand, men influence the welfare of their wife, who have higher chance to survive and to enjoy the coexistence benefit, i.e. for the same level of prevention, $\pi_M(h)\left[\Phi_M^j + \Phi_F^j\right] < \pi_F(h)\left[\Phi_M^j + \Phi_F^j\right]$, which pushes towards more prevention for men. This is taken into account by the term $\pi_M{}'\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right]$. Depending on which effect dominates, we have either $h_F^{kj} > h_M^{kj}$ or $h_F^{kj} < h_M^{kj}$.

Proposition 3 *At the first-best optimum, we have:*
(i) $c_M^{kj} = c_F^{kj} = d_M^{kj} = d_F^{kj} = \bar{c}\ \forall j \in \{C, c\}, k \in \{A, a\}$.
(ii) $h_F^{kj} \lesseqgtr h_M^{kj}$, *depending on the values of* (ε, p_M, p_F).

Proof. See the Appendix. ■

Let us now study differences between couples, by considering either men or women. It is clear, from the above conditions, that agents within type-C couples obtain higher prevention than agents who belong to type-c couples. The reason is that the former couple members create on / and obtain from their spouse a higher welfare benefit from coexistence, in comparison to agents who belong to the latter type of couples. It is thus optimal, from a utilitarian perspective, to favour these couples, as it is a more direct way to increase social welfare.[27]

The social optimum encourages prevention with respect to the laissez-faire. This is related to the non-internalized (self-oriented) coexistence concerns. In the laissez-faire, agents underinvest in prevention, as they internalize only imperfectly the effect of their decisions on the other's (self-oriented) welfare. The extent of underinvestment in prevention for an agent belonging to a couple with types (k, j) depends not only on how α^k differs from 1 (i.e. full internalization), but, also, on the survival chance of the spouse $\pi_\ell\left(h_\ell^{kj}\right)$, as well as on the size of the coexistence benefit for the couple (i.e. the magnitude of $\Phi_M^j + \Phi_F^j$).

Proposition 4 *The first-best optimum is such that:*
(i) $h_M^{Ck} > h_M^{ck}$ *and* $h_F^{Ck} > h_F^{ck}$ $\forall \alpha^k$.
(ii) if $\alpha^k < 1$*: then, ceteris paribus,* $h_M^{kjFB} > h_M^{kjLF}$ *and* $h_F^{kjFB} > h_F^{kjLF}$.

Proof. Point (i) is obtained by comparing (7) and (8) evaluated at Φ_i^C and Φ_i^c. Point (ii) is obtained by comparing (7) and (8) with (5) for the two spouses, all other variables being equal. ■

Having shown in this section that the laissez-faire equilibrium is not optimal, we show in the following section how to recover the first-best optimum by implementing the adequate tax-and-transfer scheme.

4.2 Decentralization of the first-best

We assume that instruments available to the social planner are: a tax on savings, τ_i^{kj}, on preventive expenditures, θ_i^{kj}, and a lump sum transfer, T_i^{kj}, which are type-specific, that is, they can take different values depending on the gender $i \in \{M, F\}$ and on the type (j, k) of couple, for $j \in \{C, c\}$ and $k \in \{A, a\}$.[28]

Under those policy instruments, the problem of an agent of gender $i \in \{M, F\}$ in a couple with a spouse of gender $\ell \neq i$ becomes:

$$\max_{s_i^{kj},\, h_i^{kj}} V_i^{kj}\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right)\Big|_{\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)} \text{ s.to } \begin{cases} c_i^{kj} \leq w - h_i^{kj}\left(1+\theta_i^{kj}\right) - s_i^{kj}\left(1+\tau_i^{kj}\right) + T_i^{kj} \\ d_i^{kj} \leq \tilde{R}_i^{kj} s_i^{kj} \end{cases}$$

[27] Note that, in comparison with the laissez-faire, we have a larger prevention at the first-best, *whatever* we fix $\bar{\alpha}$ to 0 or 1. Indeed, at the first-best, counting men or women once or twice does not matter, as long as all agents are counted in the same way.

[28] We still assume that the annuity market is actuarially fair so that $\tilde{R}_i^{kj} = 1/\pi_i^{kj}\left(h_i^{kj}\right)$.

and first-order conditions are now:

$$\frac{u'\left(d_i^{kj}\right)}{u'\left(c_i^{kj}\right)} = 1+\tau_i^{kj} \tag{9}$$

$$\pi_i'\left(h_i^{kj}\right)\left[\begin{array}{c} u\left(d_i^{kj}\right)-d_i^{kj}u'\left(d_i^{kj}\right)-(1-p_i)L \\ +\pi_\ell\left(h_\ell^{kj}\right)\left[\Phi_i^j+\alpha^k\Phi_\ell^j\right]\end{array}\right] = u'\left(c_i^{kj}\right)\left(1+\theta_i^{kj}\right) \tag{10}$$

Comparing these equations with the ones of the first-best (6)-(8) for both spouses, we obtain the following proposition.

Proposition 5 *The first-best optimum can be decentralized by means of the following taxes on savings and on prevention:*

$$\begin{aligned}
\tau_F^{kj} &= \tau_M^{kj}=0 \\
\theta_M^{kj} &= -\left(1-\alpha^k\right)\frac{\pi'_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j}{u'(\bar{c})}<0 \\
\theta_F^{kj} &= -\left(1-\alpha^k\right)\frac{\pi'_F\left(h_F^{kj}\right)\pi_M\left(h_M^{kj}\right)\Phi_M^j}{u'(\bar{c})}<0
\end{aligned}$$

and lump-sum transfers such that $T_M^{kC}>T_M^{kc}$ *and* $T_F^{kC}>T_F^{kc}$ $\forall k$.

Proof. Optimal tax/subsidies are obtained from comparing the above equations with the ones of the first-best (6)-(8), for all spouses. ■

The subsidy on prevention depends on the form of coexistence concerns, i.e. on Φ_ℓ^j and on α^k. If, for instance, altruism is perfect (i.e. $\alpha^k=1$), each couple member perfectly internalizes the influence he has on the other spouse's welfare, so that no subsidy is required and $\theta_M^{kj}=\theta_F^{kj}=0$. In that case, agents act exactly as the ideal couple, and equally care about their welfare and the one of their partner. The decentralization requires only lump-sum transfers towards those having higher coexistence concerns. If, on the contrary, altruism is imperfect, i.e. $\alpha^k<1\forall k$, then distortionary taxation is also necessary, and the size of θ_M^{kj} (resp. θ_F^{kj}) depends on both the magnitude of the coexistence benefit created on the other spouse, Φ_F^j (resp. Φ_M^j), and on the marginal increase in coexistence time, i.e. $\pi'_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)$ (resp. $\pi'_F\left(h_F^{kj}\right)\pi_M\left(h_M^{kj}\right)$). However, it is impossible to find whether $\left|\theta_M^{kj}\right|\gtrless\left|\theta_F^{kj}\right|$, because, in the first best, h_F^{kj} can be larger or smaller than h_M^{kj}.

The optimal subsidy on prevention is not independent from gender-specific probabilities of old-age autonomy. For instance, the more likely is man's autonomy at the old age (i.e. the higher p_M is), the larger is his wife's self-oriented coexistence benefit Φ_F^j. Under imperfect altruism, the wife's coexistence benefits are not fully internalized, and so a higher coexistence gain invites also a higher subsidy on man's prevention *ceteris paribus*.

The direction of transfers between couples with different types is here unambiguous. This results from the fact that in the first best, $h_M^{kC} > h_M^{kc}$ and $h_F^{kC} > h_F^{kc}$ (see Proposition 4), so that it is optimal to redistribute resources towards those who have higher coexistence concerns. However, inside a given couple, the direction of transfers between men and women is ambiguous and depends on whether $h_F^{kj} \lesseqgtr h_M^{kj}$, and thus on the parameters of the model, (ε, p_M, p_F). If $h_F^{kj} >$ (resp. $<$)h_M^{kj}, we have $T_F^{kj} >$ (resp. $<$)T_M^{kj}.

5 Second-best problem

Whereas Section 4 presupposed a perfect observability of the types (j, k) of couples, it is not straightforward to know *a priori* which couple is made of members exhibiting high or low self-oriented coexistence concerns, and high or low altruism. Individual preferences are hard to observe, and this motivates the study of the second-best problem, in which the social planner cannot observe the types (k, j) of couple, but can nonetheless observe genders.

5.1 Centralized solution

We set $\alpha^k = \alpha < 1, \forall k$, as we showed that differences in altruism do not affect the first-best allocation. Indeed, the paternalistic planner sets $\bar{\alpha}$ equal for all agents, and the level of α^k matters only for the size of the subsidy on prevention in the decentralized problem. Thus we also drop the superscript k.

In Section 4, we showed that preventive expenditures of a couple with Φ_i^C are always larger than the ones of a couple with Φ_i^c, $\forall i = M, F$ (see Proposition 4), while consumptions are the same. Thus, if the social planner cannot observe the welfare gain obtained from coexistence, Φ_i^j, and proposes the first-best bundles, type-c agents have interest in pretending to be of type-C, so as to benefit from higher prevention, which would be a social waste in the absence of real coexistence concerns. Hence we have to ensure that for each agent of gender $i \in \{M, F\}$ with a spouse of gender ℓ, under asymmetry of information, the second-best allocation satisfies the following incentive constraints:[29]

$$V_i^c\left(c_i^c, d_i^c, h_i^c\right)\big|_{\left(c_\ell^C, d_\ell^C, h_\ell^C\right)} \geq V_i^c\left(c_i^C, d_i^C, h_i^C\right)\big|_{\left(c_\ell^C, d_\ell^C, h_\ell^C\right)} \quad (11)$$

$$V_i^c\left(c_i^c, d_i^c, h_i^c\right)\big|_{\left(c_\ell^c, d_\ell^c, h_\ell^c\right)} \geq V_i^c\left(c_i^C, d_i^C, h_i^C\right)\big|_{\left(c_\ell^c, d_\ell^c, h_\ell^c\right)} \quad (12)$$

$$V_i^c\left(c_i^c, d_i^c, h_i^c\right)\big|_{\left(c_\ell^c, d_\ell^c, h_\ell^c\right)} \geq V_i^c\left(c_i^C, d_i^C, h_i^C\right)\big|_{\left(c_\ell^C, d_\ell^C, h_\ell^C\right)} \quad (13)$$

Condition (11) is the incentive constraint for one agent when the partner lies on his/her type. Condition (12) is the incentive constraint for one agent when the partner does not lie, whereas (13) excludes cases where both partners lie.

Couples are here made of agents with homogeneous preferences towards coexistence. Hence, if the government observes with whom one is married, the possibility for an agent, to lie on his/her type is restricted by the type declared

[29] As for decisions concerning prevention, we assume that agents play non cooperatively (no transfers are possible) and cannot agree to lie on their type so as to obtain higher prevention.

by his/her partner, so that the two declared types must be the same.[30] Therefore, condition (12) is not relevant. Furthermore, comparing (11) with (13), it is clear that only condition (13) should be binding.

Denoting μ_M and μ_F the Lagrange multipliers associated with the incentive constraint (13) for men and women, the second-best problem becomes:

$$\max_{c_i^j, d_i^j, h_i^j} \sum_j n^j \sum_i V_i^{kj} \left(c_i^{kj}, d_i^{kj}, h_i^{kj} \right) \Big|_{\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)}$$

$$\text{s.to} \begin{cases} \sum_j n^j \left[w - \sum_i c_i^j + h_i^j + \pi_i \left(h_i^j \right) d_i^j \right] \geq 0 \\ V_M^c \left(c_M^c, d_M^c, h_M^c \right)\big|_{\left(c_F^c, d_F^c, h_F^c\right)} - V_M^c \left(c_M^C, d_M^C, h_M^C \right)\big|_{\left(c_F^C, d_F^C, h_F^C\right)} \geq 0 \\ V_F^c \left(c_F^c, d_F^c, h_F^c \right)\big|_{\left(c_M^c, d_M^c, h_M^c\right)} - V_F^c \left(c_F^C, d_F^C, h_F^C \right)\big|_{\left(c_M^C, d_M^C, h_M^C\right)} \geq 0 \end{cases} \quad \text{(B)}$$

This problem is solved in the Appendix. FOCs for type-c agents yield:

$$c_M^c = d_M^c = c_F^c = d_F^c = \bar{c}^c \quad (14)$$

$$\pi_M{}' \left(h_M^c \right) \begin{bmatrix} u \left(\bar{c}^c \right) - u' \left(\bar{c}^c \right) \bar{c}^c - \left(1 - p_M \right) L \\ + \pi_F \left(h_F^c \right) \left(\Phi_M^c + \Phi_F^c \right) \end{bmatrix} = u' \left(\bar{c}^c \right) \quad (15)$$

$$\pi_F{}' \left(h_F^c \right) \begin{bmatrix} u \left(\bar{c}^c \right) - u' \left(\bar{c}^c \right) \bar{c}^c - \left(1 - p_F \right) L \\ + \pi_M \left(h_M^c \right) \left(\Phi_M^c + \Phi_F^c \right) \end{bmatrix} = u' \left(\bar{c}^c \right) \quad (16)$$

We present here a simplified version of the results where $\alpha = 1$ in incentive constraints.[31] We make that perfect altruism assumption, to be able to isolate the "pure" impact of incentive constraints on type-C agents:

$$c_M^C = d_M^C = c_F^C = d_F^C = \bar{c}^C \quad (17)$$

$$\pi_M{}' \left(h_M^C \right) \begin{bmatrix} u \left(\bar{c}^C \right) - u' \left(\bar{c}^C \right) \bar{c}^C - \left(1 - p_M \right) L \\ + \pi_F \left(h_F^C \right) \left(\Phi_M^C + \Phi_F^C \right) \dfrac{1 - \frac{\left(\mu_F + \mu_M\right)}{(1+\bar{\alpha}) n^C} \frac{\left(\Phi_M^c + \Phi_F^c\right)}{\left(\Phi_M^C + \Phi_F^C\right)}}{1 - \frac{\left(\mu_F + \mu_M\right)}{(1+\bar{\alpha}) n^C}} \end{bmatrix} = u' \left(\bar{c}^C \right) \quad (18)$$

$$\pi_F{}' \left(h_F^C \right) \begin{bmatrix} u \left(\bar{c}^C \right) - u' \left(\bar{c}^C \right) \bar{c}^C - \left(1 - p_F \right) L \\ + \pi_M \left(h_M^C \right) \left(\Phi_M^C + \Phi_F^C \right) \dfrac{1 - \frac{\left(\mu_F + \mu_M\right)}{(1+\bar{\alpha}) n^C} \frac{\left(\Phi_M^c + \Phi_F^c\right)}{\left(\Phi_M^C + \Phi_F^C\right)}}{1 - \frac{\left(\mu_F + \mu_M\right)}{(1+\bar{\alpha}) n^C}} \end{bmatrix} = u' \left(\bar{c}^C \right) \quad (19)$$

There is no distortion on consumptions, because, in the utility function, the unobserved source of heterogeneity (Φ_i^c) is additive with respect to consumption. Hence, to prevent mimicking behavior from type-c agents, it is sufficient to distort preventive expenditures of type-C agents, as these are directly related to coexistence benefits. In (18) and (19), the fraction in the last terms inside brackets always exceed unity. Hence, the trade-off between prevention and first-period consumption is distorted downward for both men and women, and prevention

[30] It is impossible for a man with Φ_M^c to pretend to be in a type-C couple without a woman with Φ_F^c pretending also to be in a type-C couple too.

[31] Full expressions are derived in the Appendix. Assuming $\alpha = 1$ is convenient to explain the impact of self-selection constraints and does not substantially affect our results.

is encouraged for type-C agents in the second-best. This can be explained as follows. Type-c agents would like to invest less in prevention, since they have smaller coexistence benefits. It is then optimal to encourage prevention for men and women with type C, as a way to make less desirable their allocation to type-c agents and to relax incentive constraints.

5.2 Decentralized solution

In the Appendix, we find the levels of the taxes on savings and prevention that decentralize the second-best optimum by comparing (14) – (19) with (9) – (10).

Proposition 6 *When agents are perfectly altruistic ($\alpha = 1$), the second-best optimum can be decentralized by the following taxes on savings and prevention:*

$$\begin{aligned}
\tau_F^j &= \tau_M^j = 0, \forall j \quad and \quad \theta_M^c = \theta_F^c = 0 \\
\theta_M^C &= -\frac{\pi_M{}'\left(h_M^C\right)\pi_F\left(h_F^C\right)}{u'\left(\bar{c}^C\right)}\left[\frac{\left(\Phi_M^C+\Phi_F^C\right)-\left(\Phi_M^c+\Phi_F^c\right)}{\frac{(1+\bar{\alpha})n^C}{(\mu_F+\mu_M)}-1}\right] < 0 \\
\theta_F^C &= -\frac{\pi_F{}'\left(h_F^C\right)\pi_M\left(h_M^C\right)}{u'\left(\bar{c}^C\right)}\left[\frac{\left(\Phi_M^C+\Phi_F^C\right)-\left(\Phi_M^c+\Phi_F^c\right)}{\frac{(1+\bar{\alpha})n^C}{(\mu_F+\mu_M)}-1}\right] < 0
\end{aligned}$$

and lump-sum transfers, $T_M^{kC} > T_M^{kc}$ and $T_F^{kC} > T_F^{kc}$ $\forall k$.

We focus here on the case in which agents are perfectly altruistic, i.e. $\alpha = 1$, so as to isolate the effect of asymmetric information on taxes. However, in the Appendix, we derive full expressions of the taxes when $\alpha < 1$. Under $\alpha = 1$, there is no need to correct for imperfect altruism, and subsidies on prevention should be zero for the mimickers (type-c agents). However, when $\alpha < 1$, we are not able to recover the usual result of "no distortion at the top".[32]

Let us now study the taxes faced by type-C agents. When $\alpha = 1$, the terms inside bracket of θ_M^C and θ_F^C are positive so that these agents face a subsidy on prevention, so as to solve the incentive problem arising under asymmetry of information.[33] By encouraging prevention, the social planner makes the allocation of a type-C agent less desirable to a type-c agent as the latter would prefer to invest less in preventive expenditure (since he obtains lower benefits from coexistence). Savings for this type are still neither taxed nor subsidized.

To sum up, and taking into account both altruism and incentive effects, we find that no agent should face a tax on savings. However, prevention should be subsidized, because of imperfect altruism. Type-c agents' prevention should be subsidized, to internalize the effect of their actions on the welfare of their spouse

[32] The reason comes from the difference between the level of altruism set to $\bar{\alpha} = 0$ or 1 in the objective function and the agents' level of altruism, α considered in the self-selection constraints. Because of this, we would actually find that, in the second-best, type-c agents should face positive subsidies on prevention, $\theta_M^c, \theta_F^c < 0$ (see the Appendix).

[33] Looking at the general expression of θ_i^C in the Appendix, it is not clear whether assuming $\alpha < 1$ reinforces the subsidisation effect due to the existence of incentive constraints or not.

(and this would be reinforced by the presence of incentive constraints). Type-C agents should face an even higher subsidy on prevention, so as to relax incentive constraints.

6 Extensions and robustness

6.1 Endogenous old-age dependency

Let us now relax the assumption of fixed probabilities of old-age autonomy, and assume instead that an agent of gender $i \in \{M, F\}$ can affect his probability of being autonomous p_i by investing h_i^{kj} in his or her health. We have

$$p_i = p_i\left(h_i^{kj}\right) \tag{20}$$

with $p_i'(\cdot) > 0$, $p_i''(\cdot) < 0$ and $0 < p_i(\cdot) < 1$. Given women's physiological advantage, we have: $p_F\left(\bar{h}\right) = p\left(\bar{h}\right) > p_M\left(\bar{h}\right) = \kappa p\left(\bar{h}\right)$ with $\kappa < 1$.

At the laissez-faire, the problem of an agent of gender $i \in \{M, F\}$ is the same as before, except that his expected lifetime welfare $V_i^{kj}\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right)$ now depends on endogenous probabilities of autonomy. From the FOCs, we have:

$$u'\left(c_i^{kj}\right) = u'\left(d_i^{kj}\right) \tag{21}$$

$$\begin{aligned}
&\pi_i'\left(h_i^{kj}\right)\left[\begin{array}{r} u\left(d_i^{kj}\right) - d_i^{kj}u'\left(d_i^{kj}\right) - \left(1 - p_i\left(h_i^{kj}\right)\right)L \\ +\pi_\ell\left(h_\ell^{kj}\right)\left[\Phi_i^j + \alpha^k\Phi_\ell^j\right] \end{array}\right] \\
&+p_i'\left(h_i^{kj}\right)\pi_i\left(h_i^{kj}\right)\left[L + \alpha^k\pi_\ell\left(h_\ell^{kj}\right)\Phi_\ell^{j\prime}\right] = u'\left(d_i^{kj}\right)
\end{aligned} \tag{22}$$

Agents have here an additional incentive to invest in health: this raises the probability of old-age autonomy. This extra effect leads to the addition of a second term on the LHS. That additional term has two parts. On the one hand, it raises the direct utility of the agent, as it lowers his probability of being dependent; on the other hand, it increases the coexistence benefits enjoyed by his spouse, thanks to the better health of the old surviving agent.

The first-best problem is the same as problem (A), except that the probabilities of old-age autonomy are now endogenous, leading to the FOCs:

$$c_M^{kj} = c_F^{kj} = d_M^{kj} = d_F^{kj} = \bar{c} \tag{23}$$

$$\begin{aligned}
&\pi_M{}'\left(h_M^{kj}\right)\left[\begin{array}{l} u\left(\bar{c}\right) - \bar{c}u'\left(\bar{c}\right) - \left(1 - p_M\right)L \\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array}\right] \\
+\ &p_M'\left(h_M^{kj}\right)\pi_M\left(h_M^{kj}\right)\left[L + \pi_F\left(h_F^{kj}\right)\Phi_F^{j\prime}\right] = \frac{\lambda}{(1+\bar{\alpha})}
\end{aligned} \tag{24}$$

$$\begin{aligned}
&\pi_F{}'\left(h_F^{kj}\right)\left[\begin{array}{l} u\left(\bar{c}\right) - \bar{c}u'\left(\bar{c}\right) - \left(1 - p_F\right)L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array}\right] \\
+\ &\pi_F\left(h_F^{kj}\right)p_F'\left(h_F^{kj}\right)\left[L + \pi_M\left(h_M^{kj}\right)\Phi_M^{j\prime}\right] = \frac{\lambda}{(1+\bar{\alpha})}
\end{aligned} \tag{25}$$

Comparing these equations with the standard case in which the probability of autonomy is exogenous (see Section 4), suggests that coexistence externalities are now larger than under exogenous probabilities of old-age autonomy. Indeed, agents not only partly internalize the effect of their prevention on the expected benefit their partner gets from coexistence, that is $\pi_i{}'\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_\ell^j$, but also they now only partly internalize that higher prevention will lead to a higher probability of autonomy, and, thus, to a higher coexistence benefit for their partner, as represented by $p_i'\left(h_i^{kj}\right)\pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_\ell^{j\prime}\left(p_i\right)$. These differences lead to higher subsidy on prevention.

Using the same procedure as in Section 4.2, we show that the decentralization of this modified first best can now be achieved by the following taxes:

$$\begin{aligned}
\tau_i^{kj} &= 0\ \forall i \\
\theta_i^{kj} &= -\left(1-\alpha^k\right)\pi_\ell\left(h_\ell^{kj}\right)\frac{\pi_i'\left(h_i^{kj}\right)\Phi_\ell^j+\pi_i\left(h_i^{kj}\right)p_i'\left(h_i^{kj}\right)\Phi_\ell^{j\prime}}{u'\left(\bar{c}\right)} < 0\ \forall i,\ell \text{ with } i\neq\ell
\end{aligned}$$

Subsidies on prevention are, *ceteris paribus*, higher than under exogenous probability of autonomy. This is a consequence of the larger coexistence externalities.

6.2 Life insurance

So far we ignored the possibility to insure oneself against the premature death of the spouse. Once such a life insurance is introduced, each individual of gender $i\in\{M,F\}$ chooses $(c_i^{kj},d_i^{kj},h_i^{kj},a_i^{kj})$, where a_i^{kj} consists of the life insurance purchased in the first period. His/her spouse then receives, in case of his death, a reimbursement $I_i^{kj}a_i^{kj}$. Assuming a perfectly competitive market for life insurance, the return from life insurance I_i^{kj} in case of death of a spouse of gender $i\in\{M,F\}$ is: $I_i^{kj}=R_i^{kj}/\left(1-\pi_i\left(h_i^{kj}\right)\right)$.

Hence, the problem of an agent of gender i in a couple with an agent of gender ℓ can be rewritten as:

$$\begin{aligned}
\max_{s_i^{kj},\,a_i^{kj},\,h_i^{kj}}\quad & u\left(c_i^{kj}\right)+\pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)u\left(d_i^{kj}\right)+\pi_i\left(h_i^{kj}\right)\left(1-\pi_\ell\left(h_\ell^{kj}\right)\right)u\left(e_i^{kj}\right) \\
& -\pi_i\left(h_i^{kj}\right)\left(1-p_i\right)L+\pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_i^j \\
& +\alpha^k\left[\begin{array}{l}
u\left(c_\ell^{kj}\right)+\pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)u\left(d_\ell^{kj}\right) \\
+\pi_\ell\left(h_\ell^{kj}\right)\left(1-\pi_i\left(h_i^{kj}\right)\right)u\left(e_\ell^{kj}\right)-\pi_\ell\left(h_\ell^{kj}\right)\left(1-p_\ell\right)L \\
+\pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_\ell^j
\end{array}\right] \\
& \text{s.to}\left\{\begin{array}{l}
c_i^{kj}\leq w-h_i^{kj}-s_i^{kj}-a_i^{kj} \\
d_i^{kj}\leq \tilde{R}_i^{kj}s_i^{kj} \\
e_i^{kj}\leq \tilde{R}_i^{kj}s_i^{kj}+I_\ell^{kj}a_\ell^{kj}
\end{array}\right.
\end{aligned}$$

where e_i^{kj} is the second-period consumption of an individual of gender i after the death of his/her spouse.

First-order conditions are:

$$\pi_\ell\left(h_\ell^{kj}\right)u'\left(d_i^{kj}\right)+\left(1-\pi_\ell\left(h_\ell^{kj}\right)\right)u'\left(e_i^{kj}\right)=u'\left(c_i^{kj}\right) \tag{26}$$

$$-u'\left(c_i^{kj}\right)+\alpha^k\pi_\ell\left(h_\ell^{kj}\right)u'\left(e_\ell^{kj}\right)\leq 0 \tag{27}$$

$$\begin{aligned}&\pi_i'\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\left[u\left(d_i^{kj}\right)-d_i^{kj}u'\left(d_i^{kj}\right)+\Phi_i^j\right]-\pi_i'\left(h_i^{kj}\right)(1-p_i)L\\&+\pi_i'\left(h_i^{kj}\right)\left(1-\pi_\ell\left(h_\ell^{kj}\right)\right)\left[u\left(e_i^{kj}\right)-d_i^{kj}u'\left(e_i^{kj}\right)\right]\\&+\alpha^k\pi_i'\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\left[u\left(d_\ell^{kj}\right)-u\left(e_\ell^{kj}\right)+u'\left(e_\ell^{kj}\right)I_i^{kj}a_i^{kj}+\Phi_\ell^j\right]=u'\left(c_i^{kj}\right)\end{aligned} \tag{28}$$

Life insurance prevents consumptions in the two periods to be equalized. The marginal utility of first-period consumption is now equalized to the *expected* marginal utility from consumption in the second period. The second condition shows that individuals buy life insurance only if they are altruistic, i.e. if $\alpha^k>0$, but not otherwise.

In this extended model, an agent's prevention does not only benefit to his/her spouse through coexistence concerns, but, also, through the life insurance he/she will receive in case of her husband's death. The first two lines of the FOC for prevention correspond to what we had in the standard model with no life insurance. The last line is related to the benefits obtained by his/her spouse, when an agent invests an additional dollar in his health. As before, if the agent survives, his/her spouse obtains utility from coexisting with him/her. However, the spouse will now have to give up the benefits from life insurance, which are modeled through $u\left(d_\ell^{kj}\right)-\left(u\left(e_\ell^{kj}\right)-u'\left(e_\ell^{kj}\right)I_i^{kj}a_i^{kj}\right)$. This last term, $u'\left(e_\ell^{kj}\right)I_i^{kj}a_i^{kj}$ is the impact of the agent's prevention on the life insurance return: when he invests more in his health, the return of the life insurance I_M^{kj} increases. Thus the net effect of life insurance on prevention is ambiguous.

Let us now study the first-best problem. This can be written as

$$\max_{c_i^{kj},d_i^{kj},h_i^{kj}}\sum_k\sum_j n^{k,j}\sum_i V_i^{kj}\left(c_i^{kj},d_i^{kj},h_i^{kj}\right)\Big|_{\left(c_\ell^{kj},d_\ell^{kj},h_\ell^{kj}\right)}$$

$$\text{s.to}\ \sum_k\sum_j n^{kj}\left[w-\sum_i\left(c_i^{kj}+h_i^{kj}+\pi_i\left(h_i^{kj}\right)\left[\pi_\ell\left(h_\ell^{kj}\right)d_i^{kj}+\left(1-\pi_\ell\left(h_\ell^{kj}\right)\right)e_i^{kj}\right]\right)\right]\geq 0$$

As previously, we set $\alpha^k=\bar{\alpha}$. It is straightforward to see that we obtain the same FOCs as in the standard problem:

$$c_M^{kj}=c_F^{kj}=d_M^{kj}=d_F^{kj}=e_M^{kj}=e_F^{kj}\ =\ \bar{c} \tag{29}$$

$${\pi_M}'\left(h_M^{kj}\right)\left[\begin{array}{c}u(\bar{c})-\bar{c}u'(\bar{c})-(1-p_M)L\\+\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j+\Phi_F^j\right]\end{array}\right]=\frac{\lambda}{(1+\bar{\alpha})} \tag{30}$$

$${\pi_F}'\left(h_F^{kj}\right)\left[\begin{array}{c}u(\bar{c})-\bar{c}u'(\bar{c})-(1-p_F)L\\+\pi_M\left(h_M^{kj}\right)\left[\Phi_M^j+\Phi_F^j\right]\end{array}\right]=\frac{\lambda}{(1+\bar{\alpha})} \tag{31}$$

Consumptions should be equalized across agents and periods. The optimal prevention is influenced both by the gender through (π_i,p_i) and by the type of couple j through Φ_i^j.

Regarding the decentralization of the first-best optimum, it should be stressed that, in the laissez-faire, consumptions are not equalized across states, because agents may receive life insurance benefits, over which they have no control, in addition to their annuitised savings. Hence, to obtain first-best consumption paths, it is optimal to tax the purchase of life insurance in such a way that the demand for it equals zero, $a_i^{kj} = 0$ and thus $d_i^{kj} = e_i^{kj}$.[34] Therefore, as far as the optimal subsidy on prevention is concerned, we are back to the formula of Proposition 5.

In sum, the introduction of life insurance influences the amount of prevention prevailing at the laissez-faire. However, the social optimum involves zero life insurance, so that it is optimal to prevent agents from buying such insurance. Hence the optimal subsidy on prevention is the same as in the baseline model.

6.3 Imperfect marriage matching

In this subsection, we assess the robustness of our results to the perfect matching assumption, by supposing, on the contrary, imperfect matching between spouses. To illustrate the effects of imperfect matching, we compare the situations of perfectly matched agents of types (A, C) and (a, c) with the ones of the most imperfectly matched couple, where the man has type (a, c) and the woman has type (A, C). In that case, the laissez-faire FOCs of the mismatched couple are:

$$u'\left(\tilde{c}_M^{ac}\right) = u'\left(\tilde{d}_M^{ac}\right) \tag{32}$$

$$\pi'_M\left(\tilde{h}_M^{ac}\right)\left[\begin{array}{l} u\left(\tilde{d}_M^{ac}\right) - \tilde{d}_M^{ac} u'\left(\tilde{d}_M^{ac}\right) - \left(1 - p_M\right) L \\ +\pi_F\left(\tilde{h}_F^{AC}\right)\left[\Phi_M^c + \alpha^a \Phi_F^C\right] \end{array}\right] = u'\left(\tilde{d}_M^{ac}\right) \tag{33}$$

for the husband, and, for the wife:

$$u'\left(\tilde{c}_F^{AC}\right) = u'\left(\tilde{d}_F^{AC}\right) \tag{34}$$

$$\pi'_F\left(\tilde{h}_F^{AC}\right)\left[\begin{array}{l} u\left(\tilde{d}_F^{AC}\right) - \tilde{d}_F^{AC} u'\left(\tilde{d}_F^{AC}\right) - \left(1 - p_F\right) L \\ +\pi_M\left(\tilde{h}_M^{ac}\right)\left[\Phi_F^C + \alpha^A \Phi_M^c\right] \end{array}\right] = u'\left(\tilde{d}_F^{AC}\right) \tag{35}$$

where the tilde refers to the allocation of the mismatched couple.

The husband of type (a, c) is likely to spend less on prevention than a husband of type (A, C), since the former internalizes less the welfare effects of his survival. Given that his wife, of type (A, C), cares a lot about his survival, the low matching quality reinforces the size of externalities associated to the choice of prevention by the husband, in comparison to the perfect sorting case with type (A, C). Note, however, that the low matching quality tends, on the contrary, to weaken the externalities related to the prevention of the wife. Indeed, the wife

[34] Let assume a unit tax on the demand for life insurance, ϑ. It should be set such that:

$$-\left(1+\vartheta\right) u'\left(w - h_M^{kj} - s_M^{kj}\right) + \alpha^k \pi_F\left(h_F^{kj}\right) u'\left(\tilde{R}_F^{kj} s_F^{kj}\right) < 0$$

which ensures that $a_i^{kj} = 0$.

of type (A, C) is likely to spend more on prevention than a wife of type (a, c). Given that her husband, of type (a, c) does not care a lot about her survival, the low quality matching weakens externalities with respect to the (a, c) perfect sorting case.

Let us now study the first-best problem, while assuming that there is only these three types of couples. Using the FOCs of the baseline model, the optimal allocation of the mismatched couple satisfies:

$$\begin{aligned}
\tilde{c}_M^{ac} = \tilde{c}_F^{AC} = \tilde{d}_M^{ac} = \tilde{d}_F^{AC} &= \bar{c} \\
\pi_M{}' \left(\tilde{h}_M^{ac}\right) \left[\begin{array}{c} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1 - p_M) L \\ +\pi_F \left(\tilde{h}_F^{AC}\right) \left[\Phi_M^c + \Phi_F^C\right] \end{array} \right] &= \frac{\lambda}{(1 + \bar{\alpha})} \\
\pi_F{}' \left(\tilde{h}_F^{AC}\right) \left[\begin{array}{c} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1 - p_F) L \\ +\pi_M \left(\tilde{h}_M^{ac}\right) \left[\Phi_M^c + \Phi_F^C\right] \end{array} \right] &= \frac{\lambda}{(1 + \bar{\alpha})}
\end{aligned}$$

Consumptions should be smoothed across periods and spouses for the mismatched couple. As to the other couples, the FOCs are exactly the same as in the baseline model. Using the results of Proposition 4 (agents with higher coexistence concerns invest more in prevention), we obtain:

$$h_M^{ac} < \tilde{h}_M^{ac} < h_M^{AC} \quad \text{and} \quad h_F^{ac} < \tilde{h}_F^{AC} < h_F^{AC}$$

It is then optimal that a husband whose wife has high coexistence concerns invests more in his health than a man whose wife has low coexistence concerns. However, it is also optimal to make him invest less in his health than if he also had high coexistence concerns. The same reasoning applies for women.

Using the same procedure as in Section 4.2., we find the following optimal taxes on prevention to be faced by a mismatched couple:

$$\tilde{\theta}_M^{ac} = -(1 - \alpha^a) \frac{\pi'_M \left(\tilde{h}_M^{ac}\right) \pi_F \left(\tilde{h}_F^{AC}\right) \Phi_F^C}{u'(\bar{c})} < 0 \tag{36}$$

$$\tilde{\theta}_F^{AC} = -\left(1 - \alpha^A\right) \frac{\pi'_F \left(\tilde{h}_F^{AC}\right) \pi_M \left(\tilde{h}_M^{ac}\right) \Phi_M^c}{u'(\bar{c})} < 0 \tag{37}$$

Comparing those taxes with the ones under perfect sorting (Proposition 5) for couples of types (a, c) and (A, C), it is not clear whether the taxes are smaller or larger when couples are mismatched than when they are perfectly matched. This depends on the level of prevention made by spouses inside the different types of couples, as well as on the levels of α^k and Φ_i^j.

All in all, the degree of marriage sorting influences optimal prevention. But the rationale for subsidizing prevention in case of self-oriented coexistence concerns and imperfect altruism remains valid. Thus, although optimal policy is affected, our results are qualitatively robust to the degree of sorting.

6.4 Myopia

In real life, individuals tend to misperceive their survival chances, as well as the impact of prevention of survival prospects. Those behavioral imperfections justify the government's intervention.[35] The goal of this subsection is to assess the robustness of our policy results when agents misperceive the survival process to which they are subject. For that purpose, let us assume that agents perceive their survival probability as being equal to $\tilde{\pi}_i(h) = \beta\pi_i(h)$ with $\beta \leq 1$, while their true probability is $\pi_i(h)$ as defined by (1).[36]

The preferences of an agent of gender $i \in \{M, F\}$ belonging to a (k, j)-type couple are now represented by:

$$\begin{aligned} V_i^{kj}\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right)\Big|_{\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right)} &= U_i\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right) + \beta^2\pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_i^j \\ &+\alpha^k\left[U_\ell\left(c_\ell^{kj}, d_\ell^{kj}, h_\ell^{kj}\right) + \beta^2\pi_\ell\left(h_\ell^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_\ell^j\right] \end{aligned}$$

where $U_i\left(c_i^{kj}, d_i^{kj}, h_i^{kj}\right) = u\left(c_i^{kj}\right) + \beta\pi_i\left(h_i^{kj}\right)\left[u\left(d_i^{kj}\right) - (1 - p_i)L\right]$.

The laissez-faire problem of an agent is the same as in our standard model except that now, he believes his survival probability is $\beta\pi_i\left(h_i^{kj}\right)$. The FOCs for an agent of gender $i \in \{M, F\}$ are now:[37]

$$u'\left(c_i^{kj}\right) = \beta u'\left(d_i^{kj}\right) \tag{38}$$

$$\pi_i'\left(h_i^{kj}\right)\left[\begin{array}{l} u\left(d_i^{kj}\right) - d_i^{kj}u'\left(d_i^{kj}\right) - (1 - p_i)L \\ +\beta\pi_\ell\left(h_\ell^{kj}\right)\left[\Phi_i^j + \alpha^k\Phi_\ell^j\right] \end{array}\right] = u'\left(d_i^{kj}\right) \tag{39}$$

Consumption is not smoothed across periods anymore, as agents prefer to consume more in the beginning of their life. Moreover, because of myopia, individuals invest *less* in prevention with respect to the standard case, since myopia makes them underestimate the probability to enjoy coexistence gains.

Turning now to the first-best problem, we assume that the social planner is paternalistic, that is, he would like to correct agents' behavior for their myopia. To do so, the planner sets $\beta = 1$ in the social objective function. The first-best optimum remains thus unchanged. Comparing the FOCs of the modified decentralized problem with FOCs (6)-(8), we obtain the following taxes:

$$\begin{aligned} \tau_i^{kj} &= \tau_i^{kj} = \beta - 1 < 0 \; \forall i \\ \theta_i^{kj} &= \frac{\pi_i'\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)}{u'(\bar{c})}\left[(\beta - 1)\Phi_i^j + \left(\beta\alpha^k - 1\right)\Phi_\ell^j\right] < 0 \; \forall i \end{aligned}$$

Savings should now be subsidized, since myopic agents do not save enough. The subsidy on prevention should be higher than in the model without myopia (see

[35] On behavioral imperfections in health-related choices, see Besley (1989). On optimal subsidization of prevention under endogenous life expectancy, see Leroux *et al.* (2011a, 2011b).

[36] We also assume, for the sake of simplicity, that agents equally misperceive their own survival probability and the one of their spouse.

[37] For the sake of simplicity, we assume here that although agents are myopic about their survival probability, they correctly estimate the return from annuitized savings, $\tilde{R}_i^{kj}$, so that $\tilde{R}_i^{kj} = 1/\pi_i\left(h_i^{kj}\right)$ as in the baseline case. This is not contradictory: agents may make mistakes about their own survival, but know perfectly the survival rate within the whole cohort.

Proposition 5), because of two reasons. First, the agent underestimates the effect of prevention on his own survival, and on his coexistence with his/her spouse (1st term in brackets). Second, he underestimates the coexistence benefits he creates on her when surviving (2nd term in brackets).

In sum, introducing myopia reinforces the need to subsidize prevention. The level of the optimal subsidy on prevention is thus affected, but our results are qualitatively robust to the introduction of myopia.

7 A cooperative household model

Although non-cooperative settings are used in various contexts, several arguments support an alternative modelling of couples, as *cooperative* entities. One reason is the Coase Theorem (1960): in the absence of transactions/bargaining costs, parties affected by an externality can agree on an allocation of resources that is Pareto-optimal and independent from the initial assignment of property rights. Hence a household could internalize coexistence externalities itself, without government's intervention. Another justification, due to Cigno (2012), takes the marriage as a commitment device, which guarantees, thanks to the divorce threat, the spouses' cooperation, and, hence, immunizes them against externalities.[38] To assess the robustness of our results to the modelling of the household, this section considers a cooperative household model, where spouses decide, on a collective basis, how to allocate their pooled resources to the various spending.

Denoting by $0 \leq \eta \leq 1$ the bargaining power of the man, and by $1-\eta$ the bargaining power of the wife, the problem of the cooperative household is:[39]

$$\max_{c_i^{kj}, d_i^{kj}, h_i^{kj}} \eta \, V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} + (1-\eta)\, V_F^{kj}\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)\Big|_{\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)}$$

$$\text{s.to } 2w - \left(c_M^{kj} + h_M^{kj} + \pi_M\left(h_M^{kj}\right) d_M^{kj} + c_F^{kj} + h_F^{kj} + \pi_F\left(h_F^{kj}\right) d_F^{kj}\right) \geq 0 \qquad \text{(C)}$$

When agents are perfectly altruistic (i.e. $\alpha^k = 1$), the household's collective objective function coincides with the utilitarian social welfare function, *whatever* the distribution of bargaining power within the household is. In that case, the non-cooperative laissez-faire coincides with the social optimum, and with the cooperative laissez-faire, for any distribution of bargaining power.

Assuming imperfect altruism (i.e. $\alpha^k < 1$), we solve this problem in the

[38] Note that those arguments are not decisive in our context. The Coase Theorem applies only to the extent that bargaining costs are limited. That assumption is strong in the present context, where each spouse may require dictatorship for choices related to their own health (on the grounds of one's full property of one's body). This would make household bargaining on health-related choices very difficult. Moreover, marriage is here a quite imperfect commitment device, since individual prevention can hardly be monitored at the household level.

[39] We assume here no bargaining costs.

Appendix. Rearranging FOCs, we obtain:

$$u'(c_M^{kj}) = u'(d_M^{kj}) = \frac{\lambda}{(1-\eta)\,\alpha^k + \eta} \tag{40}$$

$$u'(c_F^{kj}) = u'(d_F^{kj}) = \frac{\lambda}{\eta\alpha^k + (1-\eta)} \tag{41}$$

$$\pi_M{}'\left(h_M^{kj}\right)\left[\begin{array}{c} u\left(d_M^{kj}\right) - (1-p_M)\,L - u'(d_M^{kj})d_M^{kj} \\ +\pi_F\left(h_F^{kj}\right)\left(\Phi_M^j + \frac{\eta\alpha^k+(1-\eta)}{\eta+(1-\eta)\alpha^k}\Phi_F^j\right) \end{array}\right] = u'(d_M^{kj}) \tag{42}$$

$$\pi_F{}'\left(h_F^{kj}\right)\left[\begin{array}{c} u\left(d_F^{kj}\right) - (1-p_F)\,L - u'(d_F^{kj})d_F^{kj} \\ +\pi_M\left(h_M^{kj}\right)\left(\Phi_F^j + \frac{\eta+(1-\eta)\alpha^k}{\eta\alpha^k+(1-\eta)}\Phi_M^j\right) \end{array}\right] = u'(d_F^{kj}) \tag{43}$$

In the laissez-faire, consumptions should be smoothed across periods for both spouses, while they are different between spouses, depending on their bargaining power. Concerning prevention, the last term inside brackets on the LHS of (42) is smaller for men than for women when $\eta > 1/2$, which pushes toward smaller prevention for men than for women.[40]

Let us now turn to the first-best problem. Given that spouses cooperate, there is no need here to correct for externalities. However, the public intervention can be justified here on redistributive grounds. One may actually expect from the social planner to ensure that each spouse is treated in an equal way. Thus the optimal allocation corresponds to the case in which spouses have an *equal* bargaining power, which is equivalent to setting $\eta = 1/2$ in the above equations. Using the above FOCs, the first-best allocation satisfies:[41]

$$u'(c_M^{kj}) = u'(d_M^{kj}) = u'(c_F^{kj}) = u'(d_F^{kj}) = u'(\bar{c}) \tag{44}$$

$$\pi_M{}'\left(h_M^{kj}\right)\left[\begin{array}{c} u\left(\bar{c}\right) - (1-p_M)\,L - u'(\bar{c})\bar{c} \\ +\pi_F\left(h_F^{kj}\right)\left(\Phi_M^j + \Phi_F^j\right) \end{array}\right] = u'(\bar{c}) \tag{45}$$

$$\pi_F{}'\left(h_F^{kj}\right)\left[\begin{array}{c} u\left(\bar{c}\right) - (1-p_F)\,L - u'(\bar{c})\bar{c} \\ +\pi_M\left(h_M^{kj}\right)\left(\Phi_F^j + \Phi_M^j\right) \end{array}\right] = u'(\bar{c}) \tag{46}$$

which correspond to equations (6) – (8) describing our standard first-best. Consumptions should be smoothed across periods, between spouses and between agents belonging to different types of couples. As in Proposition 3, it is not clear whether $h_F^{kj} \gtrless h_M^{kj}$, as it depends on the demographic parameters, $(\varepsilon, p_{M,}p_F)$ but couples with higher coexistence concerns still always receive higher health expenditure: $h_M^{kC} > h_M^{kc}$ and $h_F^{kC} > h_F^{kc}$.

We now compare laissez-faire levels and first-best levels of prevention. For that purpose, we assume that the husband has higher bargaining power, in the laissez-faire.[42] In this case, $\eta > 1/2$ and the last term inside brackets in (42) (resp. (43)) is lower (resp. larger) than the last term inside brackets in (45) (resp.

[40] Like in Proposition 2, we cannot in general find whether $h_F^{kj} \gtrless h_M^{kj}$ as this depends on the levels of $(\varepsilon, p_{M,}p_F)$ and on whether $d_F^{kj} \lesseqgtr d_M^{kj}$.

[41] As before, the social planner will set the pure altruism parameter α^k to $\bar{\alpha} = 0$ or 1.

[42] The interpretation is symmetric in case of higher bargaining power of the woman.

(46)). Thus, in the first-best, men's preventive expenditures are higher than in the laissez-faire, while these are smaller for women. The underlying intuition goes as follows: at the laissez-faire, since the man has a higher bargaining power, his neglect of his wife's coexistence concerns leads to a prevention that is too small in comparison to what would be decided if they had equal bargaining power. On the contrary, the larger bargaining power of the man makes the women overinvest in her health at the laissez-faire.[43]

We finally show how this first-best optimum can be implemented. In fact, when bargaining power is unequally distributed within each couple, the decentralization of the utilitarian social optimum requires governmental intervention.[44] However, we can derive some necessary conditions for the decentralization of the first-best. For that purpose, we assume non-linear taxes on savings, τ_i^{kj} and on prevention, θ_i^{kj} as well as lump-sum transfers, T^{kj} which are differentiated by couples' types. We derive the problem in the Appendix and find that the decentralization of the first-best requires:

$$\tau_i^{kj} = 0, \forall i, k, j \tag{47}$$

$$\theta_M^{kj} = \frac{\pi'_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j}{u'(\bar{c})}\left[\frac{(1-2\eta)\left(1-\alpha^k\right)}{\eta+(1-\eta)\,\alpha^k}\right] \tag{48}$$

$$\theta_F^{kj} = \frac{\pi'_F\left(h_F^{kj}\right)\pi_M\left(h_M^{kj}\right)\Phi_M^j}{u'(\bar{c})}\left[\frac{(1-2\eta)\left(\alpha^k-1\right)}{\eta\alpha^k+(1-\eta)}\right] \tag{49}$$

Contrary to the decentralization scheme of Section 4.2, we now have that, depending on the distribution of bargaining power inside couples, either the husband or the wife faces a subsidy on prevention. If the man has a higher bargaining power than the wife, he should face a subsidy on prevention, while the wife should face a tax. But, in each case, the optimal level of the fiscal instrument is, in absolute value, increasing in self-oriented coexistence concerns, and decreasing in altruism α^k, as in the non-cooperative setting.

Like in our standard setup, couples with high coexistence concern receive higher lump-sum transfers. In order to avoid mimicking by type-c agents under asymmetric information, the social planner needs to subsidize more the prevention of type-C agents. Taking again our example of higher bargaining power of the husband, $\eta > 1/2$, we would find that type-C men would face a even higher subsidy, while for women belonging to this type of couples, the sign of the tax on prevention would be ambiguous (depending on whether the incentive or the bargaining power effects dominate). For type-c agents, the taxes would be identical to the ones that decentralize the first-best.

[43] Hence, at the first-best, intracouple welfare inequalities are smaller than at the laissez-faire.

[44] Due to the unique household budget constraint, we cannot ensure a perfect redistribution, between wives and husbands, within each couple.

8 Conclusions

This paper examined the design of the optimal subsidy on prevention against premature death in the presence of coexistence concerns. For that purpose, we developed a model with risky lifetime, where individuals, who belong to two-person households, care about the survival of their spouse. We compared the levels of prevention at the laissez-faire and at the utilitarian social optimum, and examined how the social optimum could be decentralized.

When individuals behave in a non-cooperative way, the optimal subsidy on prevention depends on the particular *form* of the coexistence concern. If the concern for coexistence is driven by altruism, a large part of welfare externalities involved in individual prevention are internalized by spouses, so that a limited public intervention is needed. On the contrary, if coexistence concerns are mainly self-oriented, while altruism is low, a larger subsidy is needed, as a consequence of externalities due to individual prevention. In that case, the necessity for the State to intervene is not independent from old-age dependency prospects, which affect welfare gains from coexistence.

Those results were shown to be robust to the introduction of endogenous probabilities of old-age dependency, life insurance, imperfect marriage sorting, and myopia. Furthermore, when replacing the non-cooperative household model by a cooperative household model, it remains true that the optimal subsidy on prevention depends on the degree of self-oriented coexistence concern, and on the degree of altruism, the major difference being that the optimal intervention depends now also on the inequality in bargaining power between spouses.

Thus our findings suggest that what matters for designing the optimal subsidy on prevention is not really *how much* individuals care about coexistence with the spouse, but *why* they care about it. The problem is that empirical studies on the willingness-to-pay for raising the survival chance of the spouse, such as Needleman (1976), do not tell us whether coexistence concerns are self-oriented or altruistic. One empirical strategy could be to exploit the fact that altruism concerns *all* aspects of welfare - and not only survival -, but identifying the reasons underlying actions remains difficult.[45] Those difficulties to identify the type of coexistence concerns make second-best analysis necessary. We showed that, under asymmetric information on preferences, it is necessary to subsidize the prevention of agents with high self-oriented coexistence concerns even more than at the first-best, so as to solve the incentive problem. Hence the type of coexistence concerns matters for policy, whatever this is observable or not.

Finally, it should be stressed that this study relied on some simplifying assumptions. Firstly, we had, for the sake of analytical tractability, to leave some sources of heterogeneity aside, such as earnings capacities. Secondly, we took the household structure as given, whereas that structure could be endogenized through marriage and divorce decisions. Thirdly, we focused only on the utilitarian social optimum. In the light of those limitations, much work remains to be done to characterize the optimal prevention policy under coexistence concerns.

[45] For instance, *inter vivos* transfers within a family can be interpreted either as a signal revealing the existence of pure altruism, or as resulting from family trade in a broader context.

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10 Appendix

10.1 Proof of Proposition 2

Interior solutions for h_M^{kj} and h_F^{kj} are given by:

$$\begin{aligned}
\varepsilon\pi'\left(h_M^{kj}\right)\left[u\left(d_M^{kj}\right)-d_M^{kj}u'\left(d_M^{kj}\right)-(1-p_M)L+\pi\left(h_F^{kj}\right)\left[\Phi_M^j+\alpha^k\Phi_F^j\right]\right] &= u'\left(d_M^{kj}\right)\\
\pi'\left(h_F^{kj}\right)\left[u\left(d_F^{kj}\right)-d_F^{kj}u'\left(d_F^{kj}\right)-(1-p_F)L+\varepsilon\pi\left(h_M^{kj}\right)\left[\Phi_F^j+\alpha^k\Phi_M^j\right]\right] &= u'\left(d_F^{kj}\right)
\end{aligned}$$

Using also the agents' budget constraints, one has that:

$$d_M^{kj}\left(1+\varepsilon\pi\left(h_M^{kj}\right)\right)+h_M^{kj}=d_F^{kj}\left(1+\pi\left(h_F^{kj}\right)\right)+h_F^{kj}=w$$

Using the above equality, three rankings of allocations are possible:

1. $d_F^{kj} \geq d_M^{kj}$ and $h_F^{kj} \leq h_M^{kj}$
2. $d_F^{kj} \leq d_M^{kj}$ and $h_F^{kj} \geq h_M^{kj}$
3. $d_F^{kj} \leq d_M^{kj}$ and $h_F^{kj} \leq h_M^{kj}$

with h_F^{kj} and h_M^{kj}, which also have to satisfy $\varepsilon\pi\left(h_M^{kj}\right) \leq \pi\left(h_F^{kj}\right)$. Moreover we have that $\Phi_M^j + \alpha^k\Phi_F^j \geq \Phi_F^j + \alpha^k\Phi_M^j$ under the assumption that $\Phi_M^j \geq \Phi_F^j$, so that last term inside brackets is unambiguously greater on the LHS of FOC for h_M^{kj} than on the FOC for h_F^{kj}. Hence solutions (1) to (3) are possible, and must hold with strict inequalities, under $\varepsilon < 1$.

10.2 Proof of Proposition 3

The Lagrangian $\pounds\left(c_M^{kj}, c_F^{kj}, d_F^{kj}, d_M^{kj}, h_M^{kj}, h_F^{kj}\right)$ has the following form:

$$(1+\bar{\alpha})\sum_k\sum_j n^{k,j}\sum_i u\left(c_i^{kj}\right) + \pi_i\left(h_i^{kj}\right)\left[u\left(d_i^{kj}\right) - (1-p_i)L\right] + \pi_i\left(h_i^{kj}\right)\pi_\ell\left(h_\ell^{kj}\right)\Phi_i^j$$

$$+(1+\bar{\alpha})\sum_k\sum_j n^{k,j}\lambda\left[w - \sum_i c_i^{kj} + h_i^{kj} + \pi_i\left(h_i^{kj}\right)d_i^{kj}\right]$$

First-order conditions are

$$\begin{aligned}
u'\left(c_F^{kj}\right) = u'\left(c_M^{kj}\right) = u'\left(d_M^{kj}\right) = u'\left(d_F^{kj}\right) &= \frac{\lambda}{(1+\bar{\alpha})} \\
\pi_M{}'\left(h_M^{kj}\right)\left[u\left(d_M^{kj}\right) - (1-p_M)L + \pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right]\right] &= \frac{\lambda}{(1+\bar{\alpha})}\left(1 + \pi_M{}'\left(h_M^{kj}\right)d_M^{kj}\right) \\
\pi_F{}'\left(h_F^{kj}\right)\left[u\left(d_F^{kj}\right) + (1-p_F)L + \pi_M\left(h_M^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right]\right] &= \frac{\lambda}{(1+\bar{\alpha})}\left(1 + \pi_F{}'\left(h_F^{kj}\right)d_F^{kj}\right)
\end{aligned}$$

Rearranging terms, we obtain equations (6)-(8).

In (7) and (8), the RHS are identical. As $p_M < p_F$ and $\pi\left(h_F^{kj}\right) \geq \varepsilon\pi\left(h_M^{kj}\right)$, both $h_M^{kj} > h_F^{kj}$ and $h_M^{kj} < h_F^{kj}$ are possible. This proves point (ii) of Proposition 3.

10.3 Second-best optimum

Centralised problem The Lagrangian $\pounds\left(c_M^j, c_F^j, d_F^j, d_M^j, h_M^j, h_F^j\right)$ of problem B is:

$$(1+\bar{\alpha})\sum_j n^j\left[\begin{array}{c}\sum_i u\left(c_i^j\right) + \pi_i\left(h_i^j\right)\left[u\left(d_i^j\right) - (1-p_i)L\right] + \pi_i\left(h_i^j\right)\pi_\ell\left(h_\ell^j\right)\Phi_i^j \\ +\lambda\left[w - \sum_i c_i^j + h_i^j + \pi_i\left(h_i^j\right)d_i^j\right]\end{array}\right]$$
$$+\left[\mu_F + \alpha\mu_M\right]\left[U_F\left(c_F^c, d_F^c, h_F^c\right) - U_F\left(c_F^C, d_F^C, h_F^C\right)\right]$$
$$+\left[\mu_M + \alpha\mu_F\right]\left[U_M\left(c_M^c, d_M^c, h_M^c\right) - U_M\left(c_M^C, d_M^C, h_M^C\right)\right]$$
$$+\left[\mu_F\left(\Phi_F^c + \alpha\Phi_M^c\right) + \mu_M\left(\Phi_M^c + \alpha\Phi_F^c\right)\right]\left[\pi_M\left(h_M^c\right)\pi_F\left(h_F^c\right) - \pi_M\left(h_M^C\right)\pi_F\left(h_F^C\right)\right]$$

The FOCs concerning type-c agents are:

$$
\begin{aligned}
&u'\left(c_M^c\right)=u'\left(d_M^c\right)=\frac{\lambda(1+\bar{\alpha})n^c}{(1+\bar{\alpha})n^c+(\mu_M+\alpha\mu_F)}\\
&u'\left(c_F^c\right)=u'\left(d_F^c\right)=\frac{\lambda(1+\bar{\alpha})n^c}{(1+\bar{\alpha})n^c+(\mu_F+\alpha\mu_M)}\\
&(1+\bar{\alpha})\,n^c\left[u\left(d_M^c\right)-(1-p_M)\,L+\pi_F\left(h_F^c\right)\left(\Phi_M^c+\Phi_F^c\right)-\lambda d_M^c\right]\\
&+(\mu_M+\alpha\mu_F)\left[u\left(d_M^c\right)-(1-p_M)\,L\right]\\
&+\left[\mu_F\left(\Phi_F^c+\alpha\Phi_M^c\right)+\mu_M\left(\Phi_M^c+\alpha\Phi_F^c\right)\right]\pi_F\left(h_F^c\right)=\tfrac{\lambda(1+\bar{\alpha})n^c}{\pi_M{}'\left(h_M^c\right)}\\
&(1+\bar{\alpha})\,n^c\left[u\left(d_F^c\right)-(1-p_F)\,L+\pi_M\left(h_M^c\right)\left(\Phi_M^c+\Phi_F^c\right)-\lambda d_F^c\right]\\
&+(\mu_F+\alpha\mu_M)\left[u\left(d_F^c\right)-(1-p_F)\,L\right]\\
&+\left[\mu_F\left(\Phi_F^c+\alpha\Phi_M^c\right)+\mu_M\left(\Phi_M^c+\alpha\Phi_F^c\right)\right]\pi_M\left(h_M^c\right)=\tfrac{\lambda(1+\bar{\alpha})n^c}{\pi_F{}'\left(h_F^c\right)}
\end{aligned}
$$

Although type-c agents are the mimickers, and should not face additional distortions in the second-best, it is not possible to recover exactly expressions (6) − (8) because of the presence of α into the incentive constraint. If we assume that $\alpha=1$, we obtain, after rearrangements, the same trade-offs as in the first-best.

The FOCs concerning type-C agents are:

$$
\begin{aligned}
&u'\left(c_M^C\right)=u'\left(d_M^C\right)=\frac{\lambda(1+\bar{\alpha})n^C}{(1+\bar{\alpha})n^C-(\mu_M+\alpha\mu_F)}\\
&u'\left(c_F^C\right)=u'\left(d_F^C\right)=\frac{\lambda(1+\bar{\alpha})n^C}{(1+\bar{\alpha})n^C-(\mu_F+\alpha\mu_M)}\\
&(1+\bar{\alpha})\,n^C\left[u\left(d_M^C\right)-(1-p_M)\,L+\pi_F\left(h_F^C\right)\left(\Phi_M^C+\Phi_F^C\right)-\lambda d_M^C\right]\\
&-(\mu_M+\alpha\mu_F)\left[u\left(d_M^C\right)-(1-p_M)\,L\right]\\
&-\left[\mu_F\left(\Phi_F^c+\alpha\Phi_M^c\right)+\mu_M\left(\Phi_M^c+\alpha\Phi_F^c\right)\right]\pi_F\left(h_F^C\right)=\tfrac{\lambda(1+\bar{\alpha})n^C}{\pi_M{}'\left(h_M^C\right)}\\
&(1+\bar{\alpha})\,n^C\left[u\left(d_F^C\right)-(1-p_F)\,L+\pi_M\left(h_M^C\right)\left(\Phi_M^C+\Phi_F^C\right)-\lambda d_F^C\right]\\
&-(\mu_F+\alpha\mu_M)\left[u\left(d_F^C\right)-(1-p_F)\,L\right]\\
&-\left[\mu_F\left(\Phi_F^c+\alpha\Phi_M^c\right)+\mu_M\left(\Phi_M^c+\alpha\Phi_F^c\right)\right]\pi_M\left(h_M^C\right)=\tfrac{\lambda(1+\bar{\alpha})n^C}{\pi_F{}'\left(h_F^C\right)}
\end{aligned}
$$

Assuming that $\alpha=1$, we obtain equations (17), (18) and (19).

Decentralised problem Comparing the FOCs of the decentralized problem with the second-best FOCs, we find that $\tau_F^c=\tau_M^c=\tau_F^C=\tau_M^C=0$, as well as the following values for θ_i^c, for $i\in\{M,F\}$:

$$
\theta_i^c=\frac{\pi_i'\left(h_i^c\right)\pi_\ell\left(h_\ell^c\right)\Phi_\ell^c}{u'(c_i^c)}\times\frac{(1+\bar{\alpha})\,n^c\,(\alpha-1)+\left(\alpha^2-1\right)\mu_\ell}{(1+\bar{\alpha})\,n^c+(\mu_i+\alpha\mu_\ell)}
$$

We have $\theta_M^c<0$ and $\theta_F^c<0$. Setting $\alpha=1$, we have that $\theta_M^c=\theta_F^c=0$.

Making the same comparisons for type-C, we obtain, for $i\in\{M,F\}$:

$$
\theta_i^C=\frac{\pi_i'\left(h_i^C\right)\pi_\ell\left(h_\ell^C\right)}{u'\left(c_i^C\right)\left[(1+\bar{\alpha})\,n^C-(\mu_i+\alpha\mu_\ell)\right]}\times\begin{bmatrix}(1+\bar{\alpha})\,n^C\,(\alpha-1)\,\Phi_\ell^C+\mu_i\left(\Phi_i^c-\Phi_i^C\right)\\+\mu_i\alpha\left(\Phi_\ell^c-\Phi_\ell^C\right)+\mu_\ell\left(\alpha\left(\Phi_i^c-\Phi_i^C\right)+\Phi_\ell^c-\alpha^2\Phi_\ell^C\right)\end{bmatrix}
$$

Setting $\alpha=1$, we find the expressions of Proposition 6.

10.4 Cooperative household model

Laissez-faire problem The Lagrangian $\pounds\left(c_M^{kj}, d_M^{kj}, h_M^{kj}, c_F^{kj}, d_F^{kj}, h_F^{kj}\right)$ of problem C is:

$$\begin{aligned}
&\eta\, V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} + (1-\eta)\, V_F^{kj}\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)\Big|_{\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)} \\
&+\lambda\left[2w - c_M^{kj} - h_M^{kj} - \pi_M\left(h_M^{kj}\right) d_M^{kj} - c_F^{kj} - h_F^{kj} - \pi_F\left(h_F^{kj}\right) d_F^{kj}\right]
\end{aligned}$$

which yields the following FOCs:

$$\begin{aligned}
\left[\eta\alpha^k + (1-\eta)\right] u'\left(c_F^{kj}\right) &= \left[\eta + (1-\eta)\,\alpha^k\right] u'\left(c_M^{kj}\right) \\
\left[\eta\alpha^k + (1-\eta)\right] u'\left(d_F^{kj}\right) &= \left[\eta + (1-\eta)\,\alpha^k\right] u'\left(d_M^{kj}\right)
\end{aligned}$$

$$\frac{\begin{array}{c}\left(\eta + (1-\eta)\,\alpha^k\right)\left[u\left(d_M^{kj}\right) - (1-p_M)\,L\right] - \lambda d_M^{kj} \\ +\pi_F\left(h_F^{kj}\right)\left(\eta\left(\Phi_M^j + \alpha^k\Phi_F^j\right) + (1-\eta)\left(\Phi_F^j + \alpha^k\Phi_M^j\right)\right)\end{array}}{} = \frac{\lambda}{\pi'_M\left(h_M^{kj}\right)}$$

$$\frac{\begin{array}{c}\left(\eta\alpha^k + (1-\eta)\right)\left[u\left(d_F^{kj}\right) - (1-p_F)\,L\right] - \lambda d_F^{kj} \\ +\pi_M\left(h_M^{kj}\right)\left(\eta\left(\Phi_M^j + \alpha^k\Phi_F^j\right) + (1-\eta)\left(\Phi_F^j + \alpha^k\Phi_M^j\right)\right)\end{array}}{} = \frac{\lambda}{\pi'_F\left(h_F^{kj}\right)}$$

Substituting for $u'(d_M^{kj}) = \lambda/\left[(1-\eta)\,\alpha^k + \eta\right]$ and $u'(d_F^{kj}) = \lambda/\left[\eta\alpha^k + (1-\eta)\right]$ in the last two equations respectively, we obtain (40) – (43).

Decentralised first-best allocation The decentralised problem is:

$$\max_{\substack{c_M^{kj}, c_F^{kj}, d_M^{kj}, \\ d_F^{kj}, h_M^{kj}, h_F^{kj}}} \eta\, V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} + (1-\eta)\, V_F^{kj}\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)\Big|_{\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)}$$

$$\text{s. to.}\quad \begin{array}{c} 2w - \left[c_M^{kj} + h_M^{kj}\left(1+\theta_M^{kj}\right) + \pi_M\left(h_M^{kj}\right) d_M^{kj}\left(1+\tau_M^{kj}\right)\right. \\ \left. +c_F^{kj} + h_F^{kj}\left(1+\theta_F^{kj}\right) + \pi_F\left(h_F^{kj}\right) d_F^{kj}\left(1+\tau_F^{kj}\right) + T^{kj}\right] \geq 0 \end{array}$$

where τ_i^{kj} and θ_i^{kj} are taxes on savings and on prevention and T^{kj} are lump-sum transfers given to a couple (k, j). Rearranged FOCs are thus

$$\frac{u'\left(d_F^{kj}\right)}{u'\left(c_F^{kj}\right)} = \left(1+\tau_F^{kj}\right) \quad \text{and} \quad \frac{u'\left(d_M^{kj}\right)}{u'\left(c_M^{kj}\right)} = \left(1+\tau_M^{kj}\right)$$

$$\begin{array}{c} u\left(d_M^{kj}\right) - (1-p_M)\,L - u'\left(d_M^{kj}\right) d_M^{kj} \\ +\pi_F\left(h_F^{kj}\right)\left(\Phi_M^j + \Phi_F^j\frac{\eta\alpha^k + (1-\eta)}{\eta + (1-\eta)\alpha^k}\right)\end{array} = \frac{u'\left(c_M^{kj}\right)\left(1+\theta_M^{kj}\right)}{\pi'_M\left(h_M^{kj}\right)}$$

$$\begin{array}{c} u\left(d_F^{kj}\right) - (1-p_F)\,L - u'\left(d_F^{kj}\right) d_F^{kj} \\ +\pi_M\left(h_M^{kj}\right)\left(\Phi_F^j + \frac{\eta + (1-\eta)\alpha^k}{\eta\alpha^k + (1-\eta)}\Phi_M^j\right)\end{array} = \frac{u'\left(c_F^{kj}\right)\left(1+\theta_F^{kj}\right)}{\pi'_F\left(h_F^{kj}\right)}$$

Substituting these conditions into (44) – (46) and rearranging terms we obtain (47) – (49).