Optimal Prevention when Coexistence Matters*

Marie-Louise Leroux† and Grégory Ponthière‡

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Abstract

We study the optimal subsidy on preventive expenditures against early death in an economy composed of non-cooperative two-person households, where survival with a healthy spouse matters, either because of self-oriented coexistence concerns, or because of altruism. The laissez-faire prevention levels are shown to be lower than the first-best levels, to an extent that is decreasing in spousal altruism and increasing in self-oriented coexistence concerns (and in expectations about the spouse's health at the old age). The decentralization of the social optimum requires thus a subsidy on prevention depending on the form of coexistence concerns. Under imperfect observability of preferences, incentive compatibility constraints reinforce the optimal subsidy of prevention for agents with high selfish coexistence gains.

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

JEL codes: H51, I12, I18.

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†CORE, Université catholique de Louvain. E-mail: Marie-Louise.Leroux@uclouvain.be

‡Paris School of Economics and Ecole Normale Supérieure, Paris. E-mail: gregory.ponthiere@ens.fr.

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]

From a policy perspective, the large empirical evidence supporting an impact of individuals on their life expectancy raises the issue of the optimal fiscal treatment of preventive activities. That question can be formulated as follows. Provided it can be shown empirically that some kind of prevention raises life expectancy, to what extent should it be subsidized?

To address that policy issue, a pioneer contribution by Besley (1989) argues that health-related choices are subject to various behavioral imperfections. Besley highlights that agents tend to misperceive the survival process, and adopt, as a consequence, 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) examine the design of the optimal subsidization of prevention, in a framework where agents differ in three characteristics affecting their survival prospects: their genetic background, their degree of myopia, and their productivity.[3]

Whereas those articles cast light on the determinants of the optimal subsidy on prevention, these were based on models where individuals care only about their *own* survival, but not about the survival of others. Although that assumption is analytically convenient, it is nonetheless an obvious simplification, since, in real life, individuals care a lot about the survival of others, such as their spouse, children, parents and friends. To illustrate this, 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. Despite such an empirical evidence, Man's concerns for the coexistence with others has so far remained largely unexplored, as illustrated by the absence of a mere *measure* of coexistence time.[4]

The goal of this paper is to reexamine the design of the optimal subsidy on prevention in an economy where individuals care not only about their own survival, but also about the survival of others. For that purpose, we firstly clarify what we mean by "caring" about the survival of other persons. Although empirical studies such as Blanchflower and Oswald (2004) emphasize the existence of strong coexistence concerns, there exist various ways in which a person "cares" about the survival of other persons. This may make a difference when

[1] See, among others, the studies by Auster *et al* (1969), 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] They show that the optimal subsidy on prevention depends on the degree of individual myopia, but, also, on the sign and size of externalities related to the individual prevention.

[4] One exception is Ponthiere (2007), who developed joint life expectancy statistics.

considering the design of optimal policy.

Actually, coexistence concerns can cover two distinct kinds of concerns. On the one hand, a person can exhibit what we shall call a *self-oriented* concern for coexistence with the spouse. In that case, the spouse would like his wife or her husband to survive, because the spouse enjoys the coexistence with her or his. In some sense, the other is regarded as a good to be consumed. On the other hand, a person can exhibit an *altruistic* concern for the welfare of the spouse. In that case, the person cares about the well-being of his or her partner *per se*, and the survival of the other is valued only insofar as this raises the well-being of the spouse.

Empirical studies support the existence of large coexistence concerns, but do not allow us to distinguish between self-oriented and altruistic coexistence concerns.[5] However, the precise form of the coexistence concerns may matter from a policy perspective. In case of self-oriented coexistence concerns, a person does not take his/her spouse's coexistence concern into account when choosing how much to invest in prevention. Hence, coordination problems may arise, and individual preventive behaviors may be suboptimal, inviting some public intervention. If, on the contrary, coexistence concerns are driven by altruism, agents do, when choosing their prevention, internalize, to some extent, its effects on the spouse's welfare, so that the coordination failure is less sizeable.

The present paper proposes thus to reconsider the fiscal treatment of preventive behavior in an economy where agents have those two kinds of coexistence concerns. To do so, we consider a two-period economy where the population is made of non-cooperative two-person households, each individual choosing his preventive investment on his own. Households are heterogeneous in the preferences of the spouses: households include spouses with various levels of self-oriented coexistence concerns and altruistic concerns.

Throughout this paper, the preventive effort takes 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 (i.e. difficulties to carry out daily activities such as eating, dressing, etc.). 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). Surviving with a healthy spouse is different from surviving with a dependent spouse. Hence coexistence concerns are not only about the *quantity* of the shared life, but also about its *quality*.

In sum, this study aims at analyzing the optimal subsidy on prevention in an economy of two-person non-cooperative households, and where coexistence matters in both quantitative and qualitative terms, but for different reasons: either self-oriented concerns or altruistic concerns. One can regard this study as proposing to cast a new light on the optimal design of public intervention, or on the optimal "division of labour" between the State and the family. At first

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

glance, the introduction of coexistence concerns seems to reduce the need for public intervention, in comparison to a society of individuals concerned with their own survival only. However, our study shows that it may be quite the opposite, depending on whether coexistence concerns are self-oriented or altruistic.

Anticipating on our results, we show that, at the laissez-faire, preventive expenditures chosen in non-cooperative households 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 subsidy on prevention, which depends on the form of coexistence concerns. Regarding the second-best problem, i.e. with unobservable preferences, incentive compatibility constraints reinforce the need to subsidize prevention for agents with high coexistence gains, so as to solve the self-selection problem.

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 considers the second-best problem, where individual preferences cannot be observed by the social planner. Section 6 introduces endogenous probabilities of old-age autonomy, and compares our results with the ones under a cooperative household. Section 7 concludes.

2 The model

2.1 Environment

We consider a population of individuals who are grouped in couples. For simplicity, those couples are assumed to be composed of one man and one woman.[10] All agents live a first period (of length normalized to one) with certainty, and enjoy a second period of life (also of length one), but with a probability, π. Moreover, the health status at the old age is not certain. Agents surviving to the old age (i.e. second period) will be autonomous with a probability p, and will suffer from old-age dependency with a probability $1-p$.

[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).

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

The population is heterogeneous in three characteristics:

- The gender. The society is composed of men and women, indexed by M and F. This, in particular, will have implications on agents' survival probability π_i and on their probability of autonomy, p_i with $i \in \{M, F\}$.
- The degree of altruism towards the spouse, denoted by α^k, which is different between couples, but is the same inside a given couple. For simplicity, we assume two types of couples $k \in \{A, a\}$ with $\alpha^A > \alpha^a$.
- The degree of self-oriented coexistence concern with the spouse, i.e. the utility obtained from coexisting with the partner, denoted by Φ_i^j. We assume, for simplicity, two groups of agents, $j \in \{C, c\}$, with $\Phi_i^C > \Phi_i^c$.

Below, we come back in details on these different sources of heterogeneity. In order to be able to focus on coexistence concerns, we assume that there is no other source of heterogeneity. This implies, among other things, that men and women of any couple are endowed with the same amount of resources, w.

2.2 Demography and health

When young, agents invest in their health, 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 his health.

As stressed by demographers (see Vallin 2002), women benefit from a physiological advantage, which guarantees a higher life expectancy than men for an *equal* investment in their health. Following this, we assume that the survival function takes a gender-specific form. 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 $0 < \pi_i(\cdot) < 1$.

Given women's physiological advantage, we have, for $h_M^{kj} = h_F^{kj} = \bar{h}$, that:

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

with $\varepsilon < 1$. Hence, for the same prevention $\bar{h}$, men's life expectancy, equal to $1 + \pi_M \left(\bar{h} \right)$, is strictly lower than women's life expectancy, equal to $1 + \pi_F \left(\bar{h} \right)$.

Regarding the health status at the old age, it is assumed that elderly agents can be either autonomous or dependent. We denote by p_i the probability of being autonomous at the old age, whereas $1 - p_i$ is the probability of old-age dependency, for $i \in \{M, F\}$. Those probabilities, which are gender-specific, are exogenous.[11] That assumption is in conformity with the current state of medical knowledge regarding major sources of old-age dependency. For instance,

[11] That assumption will be relaxed in Section 6.

Alzheimer's disease has not been found so far to be influenced by any obvious causal factor on which individuals could act.[12]

We assume that $p_F \geq p_M$, that is, that women's physiological advantage over men translates itself not only into a higher chance of living long, but, also, into a higher chance of being autonomous at the old age.[13]

2.3 Preferences

In standard two-period models with risky lifetime, agents are assumed to be interested in their own survival only, which simplifies the picture significantly. In that case, there are only two possible scenarios for each agent: a short life or a long life. Adding a risk about the health status at the old age leads to three possible scenarios of life: either a short life, or a long life with autonomy at the old age, or, alternatively, a long life with dependency at the old age.

In this paper, agents care not only about their own survival and health, but, also, about the survival and health of their spouse. Those coexistence concerns raise the number of possible scenarios of life. In our two-period model, the number of scenarios is increased from 3 to $3^2 = 9$ scenarios. To illustrate all possible scenarios of life, Figure 1 shows the lottery of life faced by a man.

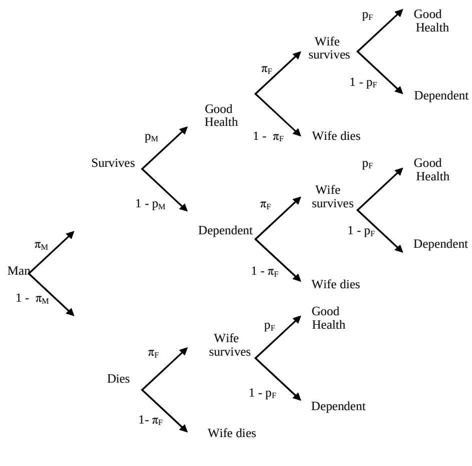

Figure 1: Man's lotery under coexistence concerns

Let us now specify the form of agents' preferences over the lotteries of life just described. For that purpose, we first assume that agents are expected utility

[12] The American National Institute of Health (2010, p. 3) states that "there is currently no evidence considered to be of even moderate scientific quality supporting the association of any modifiable factor (nutritional supplements, herbal preparations, dietary factors, prescription or nonprescription drugs, social or economic factors, medical condition, toxins, environmental exposures) with reduced risk of Alzheimer's disease."

[13] Our assumptions are in conformity with the LTC literature (Cambois *et al* 2008), showing that women have a higher disability-free life expectancy and a higher life expectancy than men.

maximizers, that is, they behave in such a way as to maximize the weighted sum of the utilities associated to each possible scenario of the lottery, with weights being the probabilities of occurrence of the different scenarios of life.[14] The occurrence of the different scenarios depends here on the survival probabilities π_M and π_F, and on the probabilities of old-age autonomy p_M and p_F.

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 $u'(\cdot) > 0$, $u''(\cdot) < 0$.

Finally, we need to specify the form of coexistence concerns, that is, how agents "care" about the survival of others. As stated in Section 1, the term "care" is quite general, as there exist various ways to "care" about the partner. In our economy, each agent cares about his partner in two distinct ways.

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.

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 (autonomous or dependent). For an agent with a degree of self-oriented coexistence concern $j \in \{C, c\}$, γ^j denotes the (self-oriented) welfare gain he/she enjoys when he/she coexists with an autonomous spouse, in comparison to the case where the spouse has not survived. Similarly, we denote by $\chi\gamma^j$ the welfare gain he/she enjoys when he/she coexists with a dependent spouse, still in comparison with the case where the spouse has not survived.[16] Agents prefer, from an egoistic perspective, to coexist with a healthy person rather than with an unhealthy person, and may also prefer coexistence with an unhealthy person to widowness, so that it is reasonable to assume that $\gamma^j > 0$ and $0 < \chi < 1$. We denote the expected welfare gain for a man (resp. a woman) of type $j \in \{C, c\}$ from the survival of his wife (resp. husband) by:

$$\begin{aligned}\Phi_M^j &= \gamma^j \left[p_F + \chi\left(1 - p_F\right)\right] \\ \Phi_F^j &= \gamma^j \left[p_M + \chi\left(1 - p_M\right)\right]\end{aligned}$$

We refer to those terms as the “self-oriented coexistence benefits”. Given that

[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] Thus, under autonomy at the old age, temporal welfare equals $u(\cdot) + \gamma^j$ when the surviving spouse is also autonomous, whereas it equals $u(\cdot) + \chi\gamma^j$ when the surviving spouse is dependent, and $u(\cdot)$ in case of widowhood.

$\gamma^C > \gamma^c$, it follows that, for two persons of the same gender i, we have $\Phi_i^C \geq \Phi_i^c$. Moreover, since women have higher probabilities of old-age autonomy (i.e. $p_F \geq p_M$), we obtain that, for an equal γ^j, the expected welfare gain from coexistence is larger for a man *ceteris paribus*, i.e. $\Phi_M^j \geq \Phi_F^j$.

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, to avoid recursive welfare across individuals. The degree of altruism of an agent of type $k \in \{A, a\}$ is captured by the parameter α^k, which equals the extent to which that agent is sensitive to his / her spouse's "private" welfare. We assume that $0 \leq \alpha^k \leq 1$, so that spouses care positively about the welfare of the partner, but do not give more weight to the welfare of their partner than to their own welfare. When $\alpha^k = 1$, spouses behave as an "ideal couple", in which case the decisions made by the husband and the wife coincide exactly with what a *unique* person would decide. But in general, we have $\alpha^k < 1$, i.e. an imperfect internalization, by agents, of the impact of their decisions on the other's welfare.

Although various couples can potentially exist, we will, for the sake of analytical tractability, assume that the couple formation process is such that agents with some degree of self-oriented coexistence concerns or altruism form couples with agents having the *same* degree of selfish coexistence concerns or altruism. This yields four types of (k, j)-couples:

- type (a, c): low altruism α^a + low self-oriented coexistence concern γ^c;
- type (a, C): low altruism α^a + high self-oriented coexistence concern γ^C;
- type (A, c): high altruism α^A + low self-oriented coexistence concern γ^c;
- type (A, C): high altruism α^A + high self-oriented coexistence concern γ^C.

Having presented how each scenario of the lottery of life will be valued by couple members, we can now collect the above assumptions, to provide a simple representation of agents' preferences on those lotteries.

The preferences of a man belonging to a (k, j)-type couple can, after simplifications, be represented by:

$$\begin{aligned} V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} &= U_M\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right) + \pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_M^j \\ &\quad + \alpha^k\left[U_F\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right) + \pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j\right] \end{aligned} \tag{3}$$

where the above function denotes the utility of a man of a (k, j)-type couple given the allocation of his wife, $\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)$. The expected lifetime welfare is here presented as a function of the three control variables of a man: his first-period consumption c_M^{kj}, his second-period consumption (if alive) d_M^{kj}, and his health investment h_M^{kj}. The function $U_M\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)$ denotes the expected lifetime welfare in the absence of coexistence concerns. It is defined as:

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

In (3), the expected lifetime welfare of a man is the sum of three terms. The first term $U_M\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)$ is the standard expected utility of the agent without coexistence concerns. The second term is the expected welfare gain from coexisting with his wife. The last term reflects altruism, as the husband also cares for the welfare of his wife.

Similarly, the expected lifetime utility of a wife in a (k,j)-type couple is:

$$\begin{aligned} V_F^{kj}\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)\Big|_{\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)} &= U_F\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right) + \pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j \\ &\quad + \alpha^k\left[U_M\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right) + \pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_M^j\right] \end{aligned} \quad (4)$$

This denotes the utility of a woman of a (k,j)-type couple given the allocation of her husband, $\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)$. Looking at the above utility functions (3) and (4), it appears that these both depend on the *joint life expectancy* of the spouses, which is equal to $1+\pi_M(\cdot)\,\pi_F(\cdot)$.[17] Note, however, that the joint life expectancy enters on two sides, which reflects the two forms of coexistence concerns. On the one hand, the joint life expectancy appears in the second terms. This captures a purely self-oriented coexistence concern. On the other hand, the joint life expectancy enters also into the third term, and this is related to altruism. Empirical evidence suggests that agents care about coexistence, but such a concern may hide very different reasons. The above functional forms account for the two distinct motivations: self-oriented coexistence concerns (second term) or altruism (third term).

Another important thing to observe at this stage is that the introduction of coexistence concerns makes each spouse's welfare dependent on the preventive investment of the partner. Even in the absence of altruism (i.e. $\alpha^k = 0$), the joint survival matters from an egoistic perspective. For instance, the wife, by investing in prevention expenditure h_F^{kj}, raises joint life expectancy and by doing so, she increases not only her expected welfare (she is more likely to benefit from second-period consumption and from the coexistence with her husband), but, also, she raises the expected lifetime welfare of her husband.

The extent to which spouses internalize the impact of their prevention on the spouse's welfare depends on the degree of altruism of agents. Under imperfect altruism, i.e. $\alpha^k < 1$, a spouse internalizes only to some extent that the partner cares about coexistence with him or her (through their joint life expectancy). As a consequence, the choice of prevention h_i^{kj} by a spouse follows from an imperfect internalization of the selfish coexistence concerns of his/her partner. Hence the levels of prevention chosen by the spouses differ from what would

[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).

maximize joint utility. This is not true under perfect altruism (i.e. $\alpha^k = 1$). In that case, individual decisions coincide with the ones taken by a unique decision-maker, and all chosen variables maximize the household's welfare, so that the coordination failure disappears.

3 The laissez-faire

Let us now examine how a decentralized economy made of two-person households behaves. We assume that agents, although being in a couple, act in a *non-cooperative* manner.[18] This approach to agents' decisions is probably a stronger assumption inside couples than outside couples. One may expect spouses to cooperate, for instance, when the decisions involve a common good, like children. However, in our context, survival is something private, and agents affect their survival prospects through individual preventive expenditures. Hence the non-cooperative model is appropriate for the decision under study.[19]

Note also that, although spouses play here non-cooperatively, they know that they interact on each others through altruism. But since altruism is imperfect, i.e. $\alpha^k < 1$, decisions within a couple of altruistic agents can still be regarded as non-cooperative, in the sense that these differ from the decisions made by a "unitary" household. Thus, even if agents form a couple, their preferred bundle is not, under $\alpha^k \neq 1$, equivalent to the one obtained from the maximization of a couple's utility under a single household budget constraint.

To describe agents' choices within a society, we focus 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 equilibrium levels of consumption and health spending 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 levels of consumption and health spending 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 at the equilibrium. Thus, no agent has an incentive to change his consumptions or prevention, even after having discovered what the other agent chooses.

Let us now characterize that equilibrium in more details. For simplicity, we assume that individual savings s_i are invested in a perfect annuity market yielding actuarially fair returns (for different risk classes), so that

$$\tilde{R}_i^{kj} = \frac{R_i^{kj}}{\pi_i\left(h_i^{kj}\right)}$$

where $\tilde{R}_i^{kj}$ is the gross return on annuitized savings, while R_i^{kj} is equal to 1 plus the interest rate. For simplicity, we suppose, in the rest of the paper, that

[18] 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".

[19] We will relax this assumption in Section 6 and see how it changes our results.

$R_i^{kj}=1$ (i.e. a zero interest rate) and that agents perfectly anticipate the impact of preventive expenditures on the return of annuitized savings.[20]

For a man, the problem consists in choosing consumptions and preventive expenditures, so as to solve the following optimization problem,

$$\max_{c_M^{kj},d_M^{kj},h_M^{kj}} V_M^{kj}\left(c_M^{kj},d_M^{kj},h_M^{kj}\right)\Big|_{\left(c_F^{kj},d_F^{kj},h_F^{kj}\right)}$$
$$\text{s.to}\left\{\begin{array}{l} c_M^{kj}\leq w-h_M^{kj}-s_M^{kj}\\ d_M^{kj}\leq \tilde{R}_M^{kj}s_M^{kj}\end{array}\right.$$

Rearranging first-order conditions yields

$$u'\left(c_M^{kj}\right)=u'\left(d_M^{kj}\right) \tag{5}$$
$$\pi_M'\left(h_M^{kj}\right)\left[\begin{array}{r} u\left(d_M^{kj}\right)-d_M^{kj}u'\left(d_M^{kj}\right)-\left(1-p_M\right)L\\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j+\alpha^k\Phi_F^j\right]\end{array}\right]=u'\left(d_M^{kj}\right) \tag{6}$$

Consumptions are smoothed across periods for men, which is a direct consequence of our assumptions on preferences and on the annuity market.

The equilibrium condition for the level of preventive expenditure sets that the direct marginal cost of increasing prevention (on the right-hand side), must equate marginal benefits (on the left-hand side). These benefits are equal to the marginal increase in utility due to a higher survival chance $\pi_M'\left(h_M^{kj}\right)u\left(d_M^{kj}\right)$, net of the decrease in the return of annuities, which is equivalent to a decrease in consumption possibilities, $\pi_M'\left(h_M^{kj}\right)d_M^{kj}u'\left(d_M^{kj}\right)$. The term $\pi_M'\left(h_M^{kj}\right)\left(1-p_M\right)L$ accounts for the additional cost related to dependency, as increasing survival chances also increases the chance to be disabled.

In addition, the level of prevention depends on the welfare gains that agents obtain from coexisting with their spouse. This is represented by the last term on the left-hand side $\pi_M'\left(h_M^{kj}\right)\left[\Phi_M^j+\alpha^k\Phi_F^j\right]$. The first term inside brackets is related to the gain the husband gets from coexisting with his wife, while the second term is related to the fact that he partly internalizes the welfare gains he creates on his wife by investing in prevention. The higher the selfish concerns (i.e. the higher Φ_M^j) and /or the higher the altruistic concern is (i.e. the higher α^k), the higher h_M^{kj} is *ceteris paribus*. Note also that this term depends on the survival probability of the wife, $\pi_F\left(h_F^{kj}\right)$. Indeed, it is only to the extent that the wife survives that the man's prevention decision matters for egoistic coexistence concerns and/or altruistic concerns. This last term of the FOC is crucial, as this makes the man's prevention dependent on the level of the wife's prevention. Actually, the higher h_F^{kj} is, the higher h_M^{kj} is *ceteris paribus* so that the reaction

[20] Another approach consists in assuming that the agent does not internalize the impact of h_i^{kj} on the annuity return (see Becker and Philipson, 1998). Given that no empirical study has yet been able to provide empirical evidence on this, we assume that such a behavioral imperfection does not take place here. See Leroux *et al* (2011) on the impact of that imperfection on optimal taxation of health spending.

curve $h_M^{kj} \equiv F(h_F^{kj})$ implicitly defined by the above FOC is strictly increasing in h_F^{kj}. Whatever the concern for coexistence is egoistic and / or altruistic, a higher survival chance of the wife makes the husband spend more on prevention.

As for women, the problem is to maximize (4) subject to

$$\begin{aligned} c_F^{kj} &\leq w - h_F^{kj} - s_F^{kj} \\ d_F^{kj} &\leq \tilde{R}_F^{kj} s_F \end{aligned}$$

We obtain

$$u'\left(c_F^{kj}\right) = u'\left(d_F^{kj}\right) \tag{7}$$

$$\pi'_F\left(h_F^{kj}\right)\left[\begin{array}{r} u\left(d_F^{kj}\right) - d_F^{kj} u'\left(d_F^{kj}\right) - (1-p_F)\, L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_F^j + \alpha^k \Phi_M^j\right] \end{array}\right] = u'\left(d_F^{kj}\right) \tag{8}$$

Those conditions are symmetric to the ones describing the husband's decisions. Here again, the prevention of the spouse, h_F^{kj}, is increasing in the prevention of the other spouse, so that the reaction curve $h_F^{kj} \equiv G(h_M^{kj})$ is increasing in h_M^{kj}.

At a Cournot-Nash equilibrium, the conditions (5), (6), (7) and (8) must necessarily be all satisfied by the levels of c_M^{kj}, d_M^{kj}, h_M^{kj}, c_F^{kj}, d_F^{kj} and h_F^{kj}. 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 (5) to (8) are satisfied. Moreover, the uniqueness of such a pair of strategies is not guaranteed, and the same is true for its stability. 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 Cournot-Nash equilibrium exists, and is unique and stable, and discuss how this differs from the social optimum. But before that, let us first note that, provided there exists a unique stable Cournot-Nash equilibrium, the conditions (5) to (8) can be used to characterize the laissez-faire allocation of 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 (5) to (8). 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 altruism* α^k*, and in the self-oriented coexistence gains* 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. ■

Note also that the laissez-faire levels of prevention h_i^{kj} 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. Thus, the more healthy the old age is expected to be, the more one will invest in prevention against early 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). Our results are summarized in the following proposition.

Proposition 2 *Assume that the market for annuities is actuarially fair. The laissez-faire allocation is such that, 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 the intuition, let us consider equations (6) and (8) assuming that consumptions are equal across periods *but* also between men and women from the same couple, i.e. that $d_F^{kj} = d_M^{kj}$. In that case, differences in prevention between men and women are driven by differences in survival and in the probability of autonomy, that is, on (ε, p_F, p_M), and by differences in the levels of coexistence benefits, $\Phi_F^j + \alpha^k \Phi_M^j$ and $\Phi_M^j + \alpha^k \Phi_F^j$. On the one hand, men have both a lower survival probability and probability of autonomy, so that, for them, the return from prevention is lower. This makes them invest less in prevention than women. On the other hand, 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 for the same level of prevention, $\pi_M(h)\left[\Phi_F^j + \alpha^k \Phi_M^j\right] < \pi_F(h)\left[\Phi_M^j + \alpha^k \Phi_F^j\right]$ as $\Phi_M^j > \Phi_F^j$. This pushes towards higher prevention for men. Depending on which effect dominates, we have $h_F^{kj} \gtrless h_M^{kj}$. This is reinforced by the fact, that, in equilibrium, consumptions are different between men and women.

4 The social optimum

In this section, we assume that the social objective is the standard utilitarian one, i.e. the sum of individual expected lifetime utilities. As this is well-known, the aggregation of utilities of agents having different preferences makes sense only if individual utilities are interpersonally comparable. In the rest of this paper, we make that assumption.[21] However, this specification can only be regarded as a starting point inviting further refinements.

[21] 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.

In our context, the specification of the social optimum raises another important issue, which concerns the treatment of altruism. As it is well-known (see Jousten *et al* 2005), it is not straightforward to see how altruistic concerns should be taken into account by the social planner. 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 equal to zero. Such a position can be defended 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, imperfect forms, but, rather, under *an ideal form*, i.e. $\bar{\alpha}$ should be fixed to 1. The underlying idea is that the planner should do *as if* couples were "ideal" couples, in which each member would be able to anticipate perfectly the impact of his actions on the welfare of his spouse.

Throughout this section, we will not adhere to the first position, as it seems unfair to make the social optimum dependent on the actual altruistic parameters. However, we will not choose here between the second and the third solutions. We will, on the contrary, impose $\alpha^k = \bar{\alpha}$ in the planner's objective function. Depending on whether one adheres to the second or the third position, one will be free to fix $\bar{\alpha} = 0$ or $\bar{\alpha} = 1$.

4.1 Centralized solution

The problem of the utilitarian social planner can be written as

$$\max_{\substack{c_M^{kj}, c_F^{kj}, d_M^{kj},\\ d_F^{kj}, h_M^{kj}, h_F^{kj}}} \sum_k \sum_j n^{k,j} \left[V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} + V_F^{kj}\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)\Big|_{\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)} \right]$$

$$\text{s.to} \sum_k \sum_j n^{kj} \left[w - \left(c_M^{kj} + h_M^{kj} + \pi_M\left(h_M^{kj}\right) d_M^{kj} + c_F^{kj} + h_F^{kj} + \pi_F\left(h_F^{kj}\right) d_F^{kj} \right) \right] \geq 0 \quad \text{(A)}$$

where $n^{k,j}$ is the number of couples with pure altruism α^k and coexistence benefit Φ_i^j. Note that in the objective function, we set $\alpha^k = \bar{\alpha}$ and show that, under $\bar{\alpha} \neq \alpha^k$, the laissez-faire equilibrium is not optimal. In the Appendix, we show that the optimal allocation satisfies

$$c_M^{kj} = c_F^{kj} = d_M^{kj} = d_F^{kj} = \bar{c} \tag{9}$$

$$\pi_M{}'\left(h_M^{kj}\right) \left[\begin{array}{c} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1 - p_M) L \\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array} \right] = \frac{\lambda}{(1+\bar{\alpha})} \tag{10}$$

$$\pi_F{}'\left(h_F^{kj}\right) \left[\begin{array}{c} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1 - p_F) L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array} \right] = \frac{\lambda}{(1+\bar{\alpha})} \tag{11}$$

Consumptions should thus be equalized between agents, whatever their gender and the type of couple they belong to, and across periods. However, the level of 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 successively the reasons for this differentiation.

Let us first concentrate 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, $\left(\Phi_M^j + \Phi_F^j\right)$ and consumptions are the same in (10) and in (11), so that the differences in preventive expenditures between men and women only result from differences in survival and in the probability of autonomy, that is on (ε, p_F, p_M). However, it is impossible to know whether $h_F^{kj} \lesseqgtr h_M^{kj}$ as this results from two countervailing effects. On the one hand, men have both a lower survival probability and probability of autonomy, which pushes toward less prevention. Thus, it is more efficient to invest in the prevention of women, since they are better able to transform preventive expenditure into welfare. 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, $\pi_M(h)\left[\Phi_M^j + \Phi_F^j\right] < \pi_F(h)\left[\Phi_M^j + \Phi_F^j\right]$. Hence, it is efficient to invest more in husbands' prevention, so as to increase the coexistence benefit of the wife, who is more likely to enjoy it. 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 $h_F^{kj} > h_M^{kj}$ or $h_F^{kj} < h_M^{kj}$. Proposition 3 summarizes our results.

Proposition 3 *At the first-best optimum, the optimal allocation of a couple with type (k, j) is such that:*
(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 Appendix B. ■

Let us now study differences between couples, by considering either men or women. It is clear, from the above conditions, that couples with high self-oriented coexistence concerns (i.e. $j = C$) obtain higher preventive expenditures than agents who belong to a couple with low self-oriented coexistence concerns (i.e. $j = c$). The reason is that the former couple members create on / and obtain from their spouse a higher welfare benefit from coexistence in comparison to the 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 the welfare of the society.

The social optimum involves higher prevention than under 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 $\pi_i\left(h_i^{kj}\right)$, as well as on the size of the coexistence benefit for the couple (i.e. the magnitude of the externality, $\Phi_M^j + \Phi_F^j$).

Note also that, in comparison with the laissez-faire, we have a higher level of prevention at the first-best, *whatever* we fix $\bar{\alpha}$ to 0 or 1. This results from the fact that, at the first-best, counting each men or women once or twice does not matter, as long as all members of couples are counted in the same way. Our results are summarized in Proposition 4.

Proposition 4 *At the first-best optimum, the optimal allocation is such that:*
(i) $h_M^{Ck} > h_M^{ck}$ *and* $h_F^{Ck} > h_F^{ck}$ $\forall \alpha^k$.
(ii) if $\alpha^k < \bar{\alpha}$: $h_M^{kjFB} > h_M^{kjLF}$ *and* $h_F^{kjFB} > h_F^{kjLF}$.

Proof. Point (i) is obtained by comparing (10) and (11) evaluated at Φ_i^C and Φ_i^c. Point (ii) is obtained by comparing (10) and (11) with (6) and (8). ■

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 $k \in \{A, a\}$.[22]

Under those policy instruments, the problem of a man becomes:

$$\max_{s_M^{kj},\, h_M^{kj}} V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)}$$
$$\text{s.to} \begin{cases} c_M^{kj} \le w - h_M^{kj}\left(1+\theta_M^{kj}\right) - s_M^{kj}\left(1+\tau_M^{kj}\right) + T_M^{kj} \\ d_M^{kj} \le \tilde{R}_M^{kj} s_M^{kj} \end{cases}$$

and first-order conditions are now:

$$\frac{u'\left(d_M^{kj}\right)}{u'\left(c_M^{kj}\right)} = 1 + \tau_M^{kj} \tag{12}$$

$$\pi'_M\left(h_M^{kj}\right)\left[\begin{array}{r} u\left(d_M^{kj}\right) - d_M^{kj} u'\left(d_M^{kj}\right) - (1-p_M)\,L \\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \alpha^k \Phi_F^j\right] \end{array}\right] = u'\left(c_M^{kj}\right)\left(1+\theta_M^{kj}\right) \tag{13}$$

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

Using the same procedure, we obtain, for women:

$$\frac{u'\left(d_F^{kj}\right)}{u'\left(c_F^{kj}\right)} = 1+\tau_F^{kj} \tag{14}$$

$$\pi'_F\left(h_F^{kj}\right)\left[\begin{array}{c} u\left(d_F^{kj}\right)-d_F^{kj}u'\left(d_F^{kj}\right)-(1-p_F)L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_F^j+\alpha^k\Phi_M^j\right]\end{array}\right] = u'\left(c_F^{kj}\right)\left(1+\theta_F^{kj}\right) \tag{15}$$

Comparing these equations with the ones of the first-best (9)-(11), 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:*

$$\tau_F^{kj} = \tau_M^{kj}=0 \tag{16}$$

$$\theta_M^{kj} = -\left(1-\alpha^k\right)\frac{\pi'_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j}{u'(\bar{c})}<0 \tag{17}$$

$$\theta_F^{kj} = -\left(1-\alpha^k\right)\frac{\pi'_F\left(h_F^{kj}\right)\pi_M\left(h_M^{kj}\right)\Phi_M^j}{u'(\bar{c})}<0 \tag{18}$$

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

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 from the couples with low coexistence concerns toward the ones with high ones. 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}.

The subsidy on prevention depends on the form of coexistence concerns, i.e. on Φ_i^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. 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^k (resp. Φ_M^k), 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}.[23]

[23] Let us consider the case where $h_F^{kj}<h_M^{kj}$, so that $\pi'_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)<$

Finally, the optimal subsidy on prevention is not independent from gender-specific probabilities of old-age autonomy and dependency. For instance, the optimal subsidy on man's prevention depends on Φ_F^j, which is increasing in the probability of man's autonomy at the old age, p_M. Thus, the more likely is man's autonomy at the old age, the larger is his wife's self-oriented coexistence benefit. 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*.[24]

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 it equal to 1 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 type-C, so as to benefit from higher preventive expenditures, which would be a social waste in the absence of real coexistence concerns. Hence we have to ensure that for each member of the couple, under asymmetry of information, the second-best allocation satisfies the

$\pi'_F\left(h_F^{kj}\right)\pi_M\left(h_M^{kj}\right)$. Since $\Phi_M^j \geq \Phi_F^j$, we have that women's prevention should be more subsidized than the one of their husbands, $\left|\theta_M^{kj}\right| < \left|\theta_F^{kj}\right|$. The reasons are twofold. First, the marginal increase in coexistence time is higher for them than for their husbands. Second, the coexistence benefit obtained by husbands from having their wives alive and in good health is higher than the one obtained by women from coexisting with their husbands (which is a direct consequence of having $p_F \geq p_M$). In the case where $h_F^{kj} > h_M^{kj}$, these two effects go in opposite directions and we cannot say whether $\left|\theta_M^{kj}\right| \gtrless \left|\theta_F^{kj}\right|$.

[24]Inversely, bad perspectives in terms of old-age dependency tend to weaken the need to subsidize prevention, since, in that case, the non-internalized welfare gains from coexistence are smaller, leading to a less serious coordination failure inside the couple.

following incentive constraints:[25]

$$V_M^c\left(c_M^c,d_M^c,h_M^c\right)\big|_{\left(c_F^C,d_F^C,h_F^C\right)} \geq V_M^c\left(c_M^C,d_M^C,h_M^C\right)\big|_{\left(c_F^C,d_F^C,h_F^C\right)} \tag{19}$$

$$V_M^c\left(c_M^c,d_M^c,h_M^c\right)\big|_{\left(c_F^c,d_F^c,h_F^c\right)} \geq V_M^c\left(c_M^C,d_M^C,h_M^C\right)\big|_{\left(c_F^c,d_F^c,h_F^c\right)} \tag{20}$$

$$V_M^c\left(c_M^c,d_M^c,h_M^c\right)\big|_{\left(c_F^c,d_F^c,h_F^c\right)} \geq V_M^c\left(c_M^C,d_M^C,h_M^C\right)\big|_{\left(c_F^C,d_F^C,h_F^C\right)} \tag{21}$$

$$V_F^c\left(c_F^c,d_F^c,h_F^c\right)\big|_{\left(c_M^C,d_M^C,h_M^C\right)} \geq V_F^c\left(c_F^C,d_F^C,h_F^C\right)\big|_{\left(c_M^C,d_M^C,h_M^C\right)} \tag{22}$$

$$V_F^c\left(c_F^c,d_F^c,h_F^c\right)\big|_{\left(c_M^c,d_M^c,h_M^c\right)} \geq V_F^c\left(c_F^C,d_F^C,h_F^C\right)\big|_{\left(c_M^c,d_M^c,h_M^c\right)} \tag{23}$$

$$V_F^c\left(c_F^c,d_F^c,h_F^c\right)\big|_{\left(c_M^c,d_M^c,h_M^c\right)} \geq V_F^c\left(c_F^C,d_F^C,h_F^C\right)\big|_{\left(c_M^C,d_M^C,h_M^C\right)} \tag{24}$$

The second and the fifth conditions are the incentive constraints of each couple member when the partner does not lie on his/her type, whereas the first and the fourth constraints denote the incentive constraint of one agent when the partner lies. The third and the sixth incentive constraints exclude cases where both partners lie. Note that, in the above functions, we have $\alpha < 1$, while the social planner sets the degree of altruism to $\bar{\alpha}$ in the social welfare function, which, as we show in appendix, creates additional distortions in the second-best allocation.

To see which incentive compatibility constraint is relevant, let us first remind that 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 by his/her partner, so that the two declared types must be the same.[26] Therefore, the second and the fifth incentive compatibility constraints are not relevant.[27] Furthermore, comparing the first and the third incentive compatibility constraints, it is clear that only the third one should be binding. The same rationale leads us to neglect the fourth incentive constraint.[28]

Denoting μ_M and μ_F the Lagrange multipliers associated with the two remaining incentive compatibility constraints, the second-best problem becomes:

$$\max_{\substack{c_M^j,c_F^j,d_M^j,\\ d_F^j,h_M^j,h_F^j}} \sum_j n^j \left[V_M^{kj}\left(c_M^{kj},d_M^{kj},h_M^{kj}\right)\Big|_{\left(c_F^{kj},d_F^{kj},h_F^{kj}\right)} + V_F^{kj}\left(c_F^{kj},d_F^{kj},h_F^{kj}\right)\Big|_{\left(c_M^{kj},d_M^{kj},h_M^{kj}\right)} \right]$$

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

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

[26] 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.

[27] The government wants to prevent the occurrence of cases described in the RHS of the conditions (mimicking), which can never happen under perfect observability of one's partner and positive assortative mating.

[28] Indeed, (21) implies (19) and (24) implies (22).

This problem is solved in the Appendix and we obtain the following first-order conditions, for type-c agents:

$$c_M^c = d_M^c = c_F^c = d_F^c = \bar{c}^c \tag{25}$$

$$\pi_M{}'(h_M^c)\left[\begin{array}{r} u(\bar{c}^c) - u'(\bar{c}^c)\bar{c}^c - (1-p_M)L \\ +\pi_F(h_F^c)(\Phi_M^c + \Phi_F^c) \end{array}\right] = u'(\bar{c}^c) \tag{26}$$

$$\pi_F{}'(h_F^c)\left[\begin{array}{r} u(\bar{c}^c) - u'(\bar{c}^c)\bar{c}^c - (1-p_F)L \\ +\pi_M(h_M^c)(\Phi_M^c + \Phi_F^c) \end{array}\right] = u'(\bar{c}^c) \tag{27}$$

We present here a simplified version of the results, assuming that $\alpha = 1$ in the incentive constraints.[29] As we mentioned above, the level of α in the incentive constraint is different from $\bar{\alpha}$ in the objective function, so that we need to make such an assumption, so as to be able to recover the usual result of "no distortion at the top" for the mimicker (i.e. type-c agents). This would not be the case otherwise. Moreover, this assumption enables us to isolate the "pure" impact of introducing incentive constraints and to see how the second-best trade-offs are modified for type-C agents:

$$c_M^C = d_M^C = c_F^C = d_F^C = \bar{c}^C \tag{28}$$

$$\pi_M{}'\left(h_M^C\right)\left[\begin{array}{l} u\left(\bar{c}^C\right) - u'\left(\bar{c}^C\right)\bar{c}^C - (1-p_M)L \\ +\pi_F\left(h_F^C\right)\left(\Phi_M^C + \Phi_F^C\right)\dfrac{1-\frac{(\mu_F+\mu_M)}{(1+\bar{\alpha})n^C}\frac{(\Phi_M^c+\Phi_F^c)}{\left(\Phi_M^C+\Phi_F^C\right)}}{1-\frac{(\mu_F+\mu_M)}{(1+\bar{\alpha})n^C}} \end{array}\right] = u'\left(\bar{c}^C\right) \tag{29}$$

$$\pi_F{}'\left(h_F^C\right)\left[\begin{array}{l} u\left(\bar{c}^C\right) - u'\left(\bar{c}^C\right)\bar{c}^C - (1-p_F)L \\ +\pi_M\left(h_M^C\right)\left(\Phi_M^C + \Phi_F^C\right)\dfrac{1-\frac{(\mu_F+\mu_M)}{(1+\bar{\alpha})n^C}\frac{(\Phi_M^c+\Phi_F^c)}{\left(\Phi_M^C+\Phi_F^C\right)}}{1-\frac{(\mu_F+\mu_M)}{(1+\bar{\alpha})n^C}} \end{array}\right] = u'\left(\bar{c}^C\right) \tag{30}$$

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 (29) and (30), 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 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 for 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 preventive expenditures that decentralize the second-best optimum by comparing (25) – (30) with (12) – (15). Proposition 6 summarizes our results.

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

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

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

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

In Proposition 6, we report the case in which agents are perfectly altruistic toward each other, i.e. $\alpha = 1$ so as to isolate the pure effect of asymmetric information on the level of taxes but in the appendix, we derive full expressions of the taxes when $\alpha < 1$.

If we assume that $\alpha = 1$, there is no need to correct for imperfect altruism, and, in that case, subsidies on prevention should be zero for the mimickers-type c agents. However, let us mention that in the general case, where $\alpha < 1$, we are not able to recover the usual result of no distortion at the top. The reason comes from the difference between the level of altruism set to $\bar{\alpha} = 0$ or 1 in the objective function and the true level of altruism, α considered in the self-selection constraints. Because of this difference, we would actually find that, in the second-best, type-c agents should face positive subsidies on preventive health, $\theta_M^c, \theta_F^c < 0$ (see Appendix C.2).

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.[30] 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. Type-c agents' prevention should be subsidized, to internalize the effect of their actions on the welfare of their spouse (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 the incentive problem.

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

6 Discussions

6.1 Endogenous old-age dependency

Up to now, the analysis relied on the postulate of fixed probabilities of old-age dependency. Let us now examine the robustness of our results to the alternative postulate, under which individual preventive expenditures can affect not only the life expectancy, but, also, the probability of autonomy at the old age. For that purpose, we will assume that an agent of gender $i \in \{M, F\}$ investing h_i^{kj} in his or her health will be autonomous in the second period with a probability:

$$p_i = p_i\left(h_i^{kj}\right) \tag{31}$$

where we assume, as usual, $p_i'(\cdot) > 0$ and $p_i''(\cdot) < 0$ and $0 < p_i(\cdot) < 1$.

Given women's physiological advantage, we have, for $h_M^{kj} = h_F^{kj} = \bar{h}$, that:

$$p_F\left(\bar{h}\right) = p\left(\bar{h}\right) > p_M\left(\bar{h}\right) = \kappa p\left(\bar{h}\right) \tag{32}$$

with $\kappa < 1$.

Under that alternative assumption, the laissez-faire problem of a man is:

$$\begin{aligned} &\max_{c_M^{kj}, d_M^{kj}, h_M^{kj}} V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} \\ &\text{s.to} \begin{cases} c_M^{kj} \leq w - h_M^{kj} - s_M^{kj} \\ d_M^{kj} \leq R_M^{kj} s_M^{kj} \end{cases} \end{aligned}$$

where we have

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

and $\Phi_M^j \equiv \Phi_M^j\left(p_F\left(h_F^{kj}\right)\right)$ and $\Phi_F^j \equiv \Phi_F^j\left(p_M\left(h_M^{kj}\right)\right)$. Solving the above problem under this new specification and rearranging first-order conditions yields

$$u'\left(c_M^{kj}\right) = u'\left(d_M^{kj}\right) \tag{33}$$

$$\begin{aligned} &\pi'_M\left(h_M^{kj}\right)\left[\begin{array}{r} u\left(d_M^{kj}\right) - d_M^{kj} u'\left(d_M^{kj}\right) - \left(1 - p_M\left(h_M^{kj}\right)\right)L \\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \alpha^k \Phi_F^j\right] \end{array}\right] \\ &+p'_M\left(h_M^{kj}\right)\pi_M\left(h_M^{kj}\right)\left[L + \alpha^k \pi_F\left(h_F^{kj}\right)\Phi_F^{j\prime}\right] = u'\left(d_M^{kj}\right) \end{aligned} \tag{34}$$

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 man as it lowers his probability of being dependent, which is associated to a lower utility; on the other hand, it increases the coexistence benefits enjoyed by the wife thanks to the better health of the old surviving husband. This latter gain is conditional on the survival of both spouses, and is weighted by the coefficient of altruistic concerns. For women, rearranged FOCs are now:

$$u'\left(c_F^{kj}\right) = u'\left(d_F^{kj}\right) \tag{35}$$

$$\pi_F'\left(h_F^{kj}\right)\left[\begin{array}{c} u\left(d_F^{kj}\right) - d_F^{kj}u'\left(d_F^{kj}\right) - (1-p_F)L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_F^j + \alpha^k\Phi_M^j\right] \end{array}\right]$$
$$+p_F'\left(h_F^{kj}\right)\pi_F\left(h_F^{kj}\right)\left[L + \alpha^k\pi_M\left(h_M^{kj}\right)\Phi_M^{j\prime}\right] = u'\left(d_F^{kj}\right) \tag{36}$$

The first-best problem is the same as problem (A), except that the probabilities of old-age autonomy are now endogenous. Taking into account this difference, we obtain the following first-order conditions :

$$c_M^{kj} = c_F^{kj} = d_M^{kj} = d_F^{kj} = \bar{c} \tag{37}$$

$$\pi_M{}'\left(h_M^{kj}\right)\left[\begin{array}{c} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1-p_M)L \\ +\pi_F\left(h_F^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array}\right]$$
$$+ \quad p_M'\left(h_M^{kj}\right)\pi_M\left(h_M^{kj}\right)\left[L + \pi_F\left(h_F^{kj}\right)\Phi_F^{j\prime}(p_M)\right] = \frac{\lambda}{(1+\bar{\alpha})} \tag{38}$$

$$\pi_F{}'\left(h_F^{kj}\right)\left[\begin{array}{c} u(\bar{c}) - \bar{c}u'(\bar{c}) - (1-p_F)L \\ +\pi_M\left(h_M^{kj}\right)\left[\Phi_M^j + \Phi_F^j\right] \end{array}\right]$$
$$+ \quad \pi_F\left(h_F^{kj}\right)p_F'\left(h_F^{kj}\right)\left[L + \pi_M\left(h_M^{kj}\right)\Phi_M^{j\prime}(p_F)\right] = \frac{\lambda}{(1+\bar{\alpha})} \tag{39}$$

Comparing these first-best equations with the laissez-faire ones, we find very similar interpretations to the ones we had in our baseline case with exogenous probabilities of autonomy. Indeed, we find that, in the first best, consumptions should be equalized between agents - whatever their type (k, j) is - as well as across periods, while in the laissez-faire, consumption is smoothed across periods but is certainly different between men and women and between members of couples with different types.

Despite those similarities, the comparison between laissez-faire and first-best levels of preventive health expenditure between men and women reveals some new differences in this alternative case. Actually, comparing (34) with (38) and (36) with (39), but also comparing these equations with the standard case in which the probability of autonomy is exogenous (see Section 4), suggests that the coordination failure is now bigger than under exogenous probabilities of old-age autonomy. Indeed, agents not only partly internalize the effect of their preventive expenditures on the expected benefit their partner gets from coexistence, that is $\pi_M{}'\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j$ in case of men, 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. In the case of a man, this is represented by the term $p_M'\left(h_M^{kj}\right)\pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^{j\prime}(p_M)$. These additional differences between the laissez-faire and the first-best prevention lead to higher subsidization of these for both men and women.

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:[31]

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

These subsidies are higher than the ones we obtain in the case of an exogenous probability of autonomy, which is a direct consequence of the higher coordination failure described previously.

6.2 A cooperative household model

Another relevant robustness check concerns the modelling of the household as the entity where decisions are made. In this paper, the couple is modelled as a non-cooperative two-person household. According to that framework, each spouse makes his own savings and prevention decisions on the basis of his or her own preferences and budget constraints. As a consequence, the spouse's preferences only enter the agent's utility function through altruistic concerns, and there is no pooling of the resources of the couple.

Although non-cooperative settings are used in various contexts (see Section 1), it remains that this is not the unique way of modelling a household. One may, on the contrary, argue that couples are *cooperative* entities. According to that alternative model, the decisions within the couple are not made by agents separately, but, on the contrary, both couple members decide together, and allocate their pooled resources to the various expenditures decided on a collective basis. Given that such a cooperative entity is also a plausible model for the family, it is worth examining the robustness of our results to that alternative modelling of the household.

For that purpose, we will here, for simplicity, turn back to the standard case where the probabilities of old-age autonomy p_i are exogenous. Denoting by $0 \leq \eta \leq 1$ the weight representing the bargaining power of the man, and $1-\eta$ the bargaining power of the wife, the problem of the cooperative household is:

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

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

When agents are perfectly altruistic (i.e. $\alpha^k = 1$), the household's collective objective function coincides with the utilitarian social welfare function, *whatever*

[31] We substitute (13) into (38) and (15) into (39).

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 Appendix D. Rearranging first-order conditions, 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 in the couple. If the man has a higher bargaining power than the women, $\eta > 1/2$, one obtains $c_F^{kj} = d_F^{kj} < c_M^{kj} = d_M^{kj}$. It is only in the case where the bargaining power is equally distributed that consumption should be equalized between members of a couple (but not between members of couples with different types (k, j)). Concerning prevention, we obtain that the last term inside brackets on the right-hand side of (42) is smaller for men than for women when $\eta > 1/2$, which pushes toward higher prevention for the man than for the women when he has higher bargaining power.[32]

Let us now turn to the first-best problem. Given that spouses cooperate, there is no need here for the social planner to correct for coordination failures. However, the intervention of a social planner can be justified here on other grounds. One may actually expect from the social planner to ensure that each spouse is treated in the same way. In that case, the optimal allocation is the one that corresponds to the case in which spouses have an *equal* bargaining power, which is equivalent to setting $\eta = 1/2$ in the above equations. As before, the social planner will set the pure altruism parameter α^k to $\bar{\alpha} = 0$ or 1. Using directly the above FOCs, the first-best allocation must satisfy

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

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

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

[32] Like in Proposition 2, we cannot in general find whether $h_F^{kj} \gtreqless h_M^{kj}$ as this depends on the levels of (ε, p_M, p_F) and on whether $d_F^{kj} \lesseqgtr d_M^{kj}$.

which correspond to equations (9)−(11) describing our standard first best. Under that formulation of equal bargaining power and of perfect altruism, consumptions should be smoothed across periods, between spouses and between agents belonging to different types of couples, so that $c_i^{kj} = d_i^{kj} = \bar{c}, \forall k, j$. As in Proposition 3, it is not clear whether $h_F^{kj} \gtrless h_M^{kj}$, as it depends on the demography parameters, (ε, 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.[33] In this case, $\eta > 1/2$ and the last term inside brackets in (42) (resp. (43)) is greater (resp. lower) than the last term inside brackets in (45) (resp. (46)). Thus, in the first best, men's preventive health expenditures are smaller than in the laissez-faire, while these are larger for women.

We finally show how this first-best optimum can be implemented. In fact, when bargaining power is unequally distributed within each couple, the social optimum cannot be fully decentralized.[34] 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 preventive expenditure, θ_i^{kj} as well as lump-sum transfers, T^{kj} which are differentiated by couples' types. We derive the decentralized problem in Appendix and find that the decentralization of the first-best requires the following tax and transfer scheme:

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

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

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

As in the standard set up, the optimal subsidy on prevention is decreasing in the degree of altruism, but increasing in self-oriented coexistence concerns. However, contrary to the decentralization scheme of Section 4.2, we now have that depending on the bargaining power inside couples, either the husband or the wife faces a subsidy on prevention. Indeed, if the man has a higher initial bargaining power he should face a tax while at the same time, the wife faces a subsidy. In the alternative case where $\eta < 1/2$, women's preventive expenditures are taxed while the ones of men are subsidized. Finally, we still do not need taxation of savings.

Like in our standard setup, couples with high coexistence concern receive higher lump-sum transfers, which would lead to the same type of second-best problem if there were asymmetric information on couples' types. In that case, so as to avoid mimicking by low-coexistence concern agents, the social planner needs to subsidize more the prevention of high-coexistence concerns agents. Taking

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

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

again our example of higher bargaining power of the husband, $\eta > 1/2$, we would find that women with high coexistence concerns would face a even higher subsidy, while for men 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 low-coexistence benefits agents, the taxes would be identical to the ones that decentralize the first best.

7 Conclusions

In the light of the available empirical evidence, it is unquestionable that individuals care not only about their own survival, but, also, about the survival of others.[35] Obviously coexistence time matters for human well-being. However, despite largely documented coexistence concerns, no theoretical study has so far explored the consequences of coexistence concerns on optimal policy-making, and, in particular, on the optimal prevention against early death.

The present paper examined the design of the optimal subsidy of preventive expenditures in the presence of coexistence concerns. As such, this study proposed to revisit, from a new perspective, the well-known debate of the optimal public intervention. Do coexistence concerns invite *more* public intervention in comparison to a society of individuals who care about their own survival only, or do coexistence concern require *less* public intervention?

To answer that question, we developed a two-period economy with risky lifetime and risky old-age health status, and where individuals belong to non-cooperative two-person households. Then, we compared the levels of prevention under that non-cooperative framework with what prevails at the utilitarian social optimum, and examined how the social optimum could be decentralized. The size of the optimal subsidy on prevention was shown to depend on the particular *form* of the coexistence concern. If the concern for coexistence is driven by altruism, then a large part of the welfare externalities involved in individual preventive spending 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, since a serious coordination failure within the couple arises, as a consequence of non-internalized welfare externalities due to individual preventive behavior. In that case, the necessity for the State to intervene is not independent from old-age dependency prospects, since these determine directly the welfare gains from coexistence.

Those results were shown to be globally robust to the introduction of endogenous probabilities of old-age dependency. Furthermore, when replacing the non-cooperative household model by a cooperative household model, it remains true that the optimal subsidy on prevention is decreasing in the degree of altruism, and increasing in the degree of self-oriented coexistence concerns, the major difference being that the optimal subsidy depends now also on the inequality in bargaining powers between the spouses.

Thus our findings suggest that what matters for designing the optimal sub-

[35] See Blanchflower and Oswald (2004), and Braakmann (2009).

sidy on prevention is not really *how much* individuals care about coexistence with the spouse, but, rather, *why* they care about it. The problem is that empirical studies do not allow us so far to provide an answer to the second question, that is, to distinguish between self-oriented coexistence concerns and altruistic coexistence concerns. For instance, empirical studies on the willingness-to-pay for raising the survival probability of the spouse (e.g. Needleman 1976) do not tell us what motivation lies behind coexistence concerns. The difficulties to observe the reasons behind 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.

In sum, this paper highlights that, under simple, but realistic, assumptions about agents' welfare, the presence of coexistence concerns within couples invites a subsidization of prevention, as a way to solve the intra-household coordination failure resulting from uninternalized self-oriented coexistence concerns. The size of the optimal subsidy on prevention was shown to depend strongly on the structure of welfare interdependencies in the population, whatever that structure is observable or not.

Note, however, 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. It would be worth examining the consequences of wage heterogeneity in terms of policy. Secondly, we considered here a society composed exclusively of couples, and this excluded single persons. One may want to know what optimal prevention becomes in a mixed society. Thirdly, we focused on the utilitarian social optimum. Obviously, when considering issues of survival under a heterogeneous population, such an aggregative social objective may lead to corollaries in contradiction with more egalitarian intuitions, so that other social objective should also be considered. In the light of those limitations, much work remains to be done to characterize the optimal prevention policy in the presence of coexistence concerns.

8 References

Apps P. F. & Rees, R., 1988. 'Taxation and the household', Journal of Public Economics, 35, 355-369.

Apps P. F. & Rees, R., 1999. 'Individual versus joint taxation in models of household production', Journal of Political Economy, 107, 178-190.

Apps P. F. & Rees, R., 2007. 'The taxation of couples', IZA Discussion Paper 2910.

Auster, R., Levenson, I. & D. Sarachek, 1969. 'The production of health: an exploratory study', Journal of Human Resources, 4, 411-436.

Balia, S. & Jones, A., 2008. 'Mortality, lifestyles and socio-economic status', Journal of Health Economics, 27 (1), 1-26.

Becker, G.S., 1974, 'A theory of social interactions', Journal of Political Economy, 82, 1063-1093.

Becker GS, Philipson T, 1998. 'Old age longevity and mortality contingent claims.' Journal of Political Economy, 106, 551–573.

Besley, T., 1989. ‘Ex ante evaluation of health states and the provision fo ill-health’, Economic Journal, 99, 132-146.

Blanchflower, D. & Oswald, A., 2004. ‘Well-being over time in Britain and the USA.’ Journal of Public Economics, 88, 1359-1386.

Boskin, M. & Sheshinski, E., 1983. ‘Optimal tax treatment of the family: married couples.’ Journal of Public Economics, 20, 281-297.

Braakmann, N., 2009. ‘Other-regarding preferences, spousal disability and happiness - evidence from German couples’, University of Luneburg Working Paper 130.

Bragstad, T., 1989. ‘On the significance of standards for the division of work in the household’, mimeo, University of Oslo.

Browning, M., 2000. ‘The saving behaviour of a two-person household’, Scandinavian Journal of Economics, 102 (2), 235-251.

Cambois, E., Clavel A., Romieu I. & Robine J-M. , 2008. ‘Trends in disability free life expectancy at age 65 in France: consistent and diverging patterns according to the underlying disability measure’, European Journal of Ageing, 5, 287-298.

Chen, Z., and Wooley, F. (2001): ‘A Cournot-Nash model of family decision making’, Economic Journal, 111, 474, 722-748.

Contoyannis, P. and A. Jones, 2004. ‘Socio-economic status, health and lifestyle’, Journal of Health Economics, 23 (5), 965-995.

Cremer, H., Lozachmeur, J-M. & Pestieau P., 2007. ‘Income taxation of couples and the tax unit choice’, CORE Discussion Paper 2007-13.

D’Aspremont C. & Dos Santos Ferreira, R., 2009. ‘Household behavior and individual autonomy’, CORE Discussion Paper 2009-22.

Del Boca, D. and Flinn, C., 1994. ‘Expenditure decisions of divorced mothers and income composition’, Journal of Human Resources, 29 (3) 742-761.

Hammond, P., 1987. ‘Altruism’, in The New Palgrave: A dictionary of economics, edited by J. Eatwell, M. Milgate and P. Newman, Macmillan, 85-86.

Jousten, A., Lipszyc, B., Marchand, M. & Pestieau, P., 2005. ‘Long-term care insurance and optimal taxation for altruistic children’, FinanzArchiv - Public Finance Analysis, 61, 1-18.

Kaplan, G., Seeman, T., Cohen, R., Knudsen, L., & Guralnik, J., 1987. ‘Mortality among the elderly in the Alameda county study: behavioural and demographic risk factors.’ American Journal of Public Health, 77 (3), 307-312.

Kleven, H.J, Kreiner, C.T. & Saez, E., 2006. ‘The optimal income taxation of couples’, NBER Working Paper 12685.

Konrad, K. and Lommerud, K., 1995. ‘Family policy with non-cooperative families’, Scandinavian Journal of Economics, 97, 581-601.

Leroux, M-L. & Ponthiere, G., 2009. ‘Optimal Tax Policy and Expected Longevity: A Mean and Variance Utility Approach’, International Tax and Public Finance, 16(4), 514-537.

Leroux, M-L., Pestieau, P. & Ponthiere, G., 2011a. ‘Optimal linear taxation under endogenous longevity’, Journal of Population Economics, 24(1), 213-237.

Leroux, M-L., Pestieau, P. & Ponthiere, G., 2011b. ‘Longevity, genes and efforts: an optimal taxation approach to prevention’, Journal of Health Economics, 30, 62-76.

Mirrlees, J., 1982. ‘The economic uses of utilitarianism’, in A.K. Sen & B. Williams (Eds.), Utilitarianism and Beyond, chapter 3 (pp. 63-84), Cambridge University Press.

Mullahy, J. and P. Portney, 1990. ‘Air pollution, cigarette smoking and the production of respiratory health’, Journal of Health Economics, 9, 193-205.

Mullahy, J. and J. Sindelar, 1996. 'Employment, unemployment, and problem drinking', Journal of Health Economics, 15, 409-434.

National Health Service, 2010. 'NHS State-of-the-science conference statement: preventing Alzheimer's disease and cognitive decline April 26-28 2010'.

Needleman, L., 1976. 'Valuing other people's lives'. The Manchester School, 44, 309-342.

Pestieau, P. & Sato, M., 2008. 'Long term care: the State, the Market and the Family', Economica, 75, 435-454.

Ponthiere, G., 2007. 'Measuring longevity achievements under welfare interdependencies: a case for joint life expectancy indicators', Social Indicators Research, 84(2), 203-230.

Tauchen, H., Witte, A. and Long, S., 1991. 'Domestic violence: a non-random affair', International Economic Review, 32 (2), 491-511.

Ulph, D., 1988. 'A general noncooperative Nash model of household behaviour', mimeo, University of Bristol.

Vallin, J., 2002. 'Mortalité, sexe et genre', in G. Caselli, J. Vallin and G. Wunsch (eds.): Démographie. Amalyse et Synthèse III: la Mortalité (chapter 53), INED, Paris.

Woolley, F., 1988. 'A non-cooperative model of family decision making', TIDI Working Paper 125, London School of Economics.

9 Appendix

9.1 Proof of Proposition 2

Interior solutions for h_M^{kj} and h_F^{kj} are given by (6) and (8),

$$\begin{aligned}\varepsilon\pi'\left(h_M^{kj}\right)\left[u\left(d_M^{kj}\right)-d_M^{kj}u'\left(d_M^{kj}\right)-(1-p_M)L+\pi\left(h_F^{kj}\right)\left[\Phi_M^j+\alpha^k\Phi_F^j\right]\right]-u'\left(d_M^{kj}\right) &= \\ \pi'\left(h_F^{kj}\right)\left[u\left(d_F^{kj}\right)-d_F^{kj}u'\left(d_F^{kj}\right)-(1-p_F)L+\varepsilon\pi\left(h_M^{kj}\right)\left[\Phi_F^j+\alpha^k\Phi_M^j\right]\right]-u'\left(d_F^{kj}\right) &= 0\end{aligned} \tag{50}$$

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 left-hand side of (50) than on the right-hand side. Replacing into(50), solutions (1) to (3) are possible and it has to hold with strong inequalities, under $\varepsilon<1$.

9.2 First-best optimum

Replacing for the expressions of (3) and (4) and rearranging terms, the Lagrangian has the following form

$$\pounds\left(c_M^{kj}, c_F^{kj}, d_F^{kj}, d_M^{kj}, h_M^{kj}, h_F^{kj}\right) =$$

$$(1+\bar{\alpha})\sum_k\sum_j n^{k,j} \left[\begin{array}{l} u\left(c_M^{kj}\right)+\pi_M\left(h_M^{kj}\right)\left[u\left(d_M^{kj}\right)-(1-p_M)\,L\right] \\ u\left(c_F^{kj}\right)+\pi_F\left(h_F^{kj}\right)\left[u\left(d_F^{kj}\right)-(1-p_F)\,L\right] \\ +\pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\left[\Phi_F^j+\Phi_M^j\right] \\ +\lambda\left[w-\left(\begin{array}{c} c_M^{kj}+h_M^{kj}+\pi_M\left(h_M^{kj}\right)d_M^{kj} \\ +c_F^{kj}+h_F^{kj}+\pi_F\left(h_F^{kj}\right)d_F^{kj}\end{array}\right)\right]\end{array}\right]$$

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 (9)-(11).

In equations (10) and (11), 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.

9.3 Second-best optimum

9.3.1 Centralised problem

The Lagrangian of problem B is:

$$\begin{aligned} \pounds\ &\left(c_M^j, c_F^j, d_F^j, d_M^j, h_M^j, h_F^j\right) = \\ &(1+\bar{\alpha})\sum_j n^j \left[\begin{array}{l} u\left(c_M^j\right)+\pi_M\left(h_M^j\right)\left[u\left(d_M^j\right)-(1-p_M)\,L\right] \\ u\left(c_F^j\right)+\pi_F\left(h_F^j\right)\left[u\left(d_F^j\right)-(1-p_F)\,L\right] \\ +\pi_M\left(h_M^j\right)\pi_F\left(h_F^j\right)\left[\Phi_F^j+\Phi_M^j\right] \\ +\lambda\left[w-\left\{c_M^j+h_M^j+\pi_M\left(h_M^j\right)d_M^j+c_F^j+h_F^j+\pi_F\left(h_F^j\right)d_F^j\right\}\right]\end{array}\right] \\ &+\left[\mu_F+\alpha\mu_M\right]\left[U_F\left(c_F^c, d_F^c, h_F^c\right)-U_F\left(c_F^C, d_F^C, h_F^C\right)\right] \\ &+\left[\mu_M+\alpha\mu_F\right]\left[U_M\left(c_M^c, d_M^c, h_M^c\right)-U_M\left(c_M^C, d_M^C, h_M^C\right)\right] \\ &+\left[\mu_F\left(\Phi_F^c+\alpha\Phi_M^c\right)+\mu_M\left(\Phi_M^c+\alpha\Phi_F^c\right)\right]\left[\pi_M\left(h_M^c\right)\pi_F\left(h_F^c\right)-\pi_M\left(h_M^C\right)\pi_F\left(h_F^C\right)\right] \end{aligned}$$

Differentiating this expression with respect to $(c^c_M, c^c_F, d^c_F, d^c_M, h^c_M, h^c_F)$, we obtain

$$u'\left(c^c_M\right) = u'\left(d^c_M\right) = \frac{\lambda(1+\bar{\alpha})n^c}{(1+\bar{\alpha})n^c + (\mu_M + \alpha\mu_F)} \tag{51}$$

$$u'\left(c^c_F\right) = u'\left(d^c_F\right) = \frac{\lambda(1+\bar{\alpha})n^c}{(1+\bar{\alpha})n^c + (\mu_F + \alpha\mu_M)} \tag{52}$$

$$\pi_M{}'\left(h^c_M\right)\left[\begin{array}{l} (1+\bar{\alpha})\, n^c \left[u\left(d^c_M\right) - (1-p_M)\, L + \pi_F\left(h^c_F\right)\left(\Phi^c_M + \Phi^c_F\right) - \lambda d^c_M\right] \\ + (\mu_M + \alpha\mu_F)\left[u\left(d^c_M\right) - (1-p_M)\, L\right] \\ + \left[\mu_F\left(\Phi^c_F + \alpha\Phi^c_M\right) + \mu_M\left(\Phi^c_M + \alpha\Phi^c_F\right)\right]\pi_F\left(h^c_F\right) \end{array}\right] = \lambda(1+\bar{\alpha})n^c \tag{53}$$

$$\pi_F{}'\left(h^c_F\right)\left[\begin{array}{l} (1+\bar{\alpha})\, n^c \left[u\left(d^c_F\right) - (1-p_F)\, L + \pi_M\left(h^c_M\right)\left(\Phi^c_M + \Phi^c_F\right) - \lambda d^c_F\right] \\ + (\mu_F + \alpha\mu_M)\left[u\left(d^c_F\right) - (1-p_F)\, L\right] \\ + \left[\mu_F\left(\Phi^c_F + \alpha\Phi^c_M\right) + \mu_M\left(\Phi^c_M + \alpha\Phi^c_F\right)\right]\pi_M\left(h^c_M\right) \end{array}\right] = \lambda(1+\bar{\alpha})n^c \tag{54}$$

Note that even though type-c agents are the mimickers and should not face additional distorsions in the second best, it is not possible to recover exactly expressions (9) − (11) because of the presence of α into the incentive constraint. If we assume that $\alpha = 1$, we obtain after some rearrangements the same trade-offs as in the first best.

Let now turn to the second best trade-offs for type-1 agent. Differentiating it with respect to $\left(c^C_M, c^C_F, d^C_F, d^C_M, h^C_M, h^C_F\right)$, we obtain

$$u'\left(c^C_M\right) = u'\left(d^C_M\right) = \frac{\lambda(1+\bar{\alpha})n^C}{(1+\bar{\alpha})n^C - (\mu_M + \alpha\mu_F)} \tag{55}$$

$$u'\left(c^C_F\right) = u'\left(d^C_F\right) = \frac{\lambda(1+\bar{\alpha})n^C}{(1+\bar{\alpha})n^C - (\mu_F + \alpha\mu_M)} \tag{56}$$

$$\pi_M{}'\left(h^C_M\right)\left[\begin{array}{l} (1+\bar{\alpha})\, n^C \left[u\left(d^C_M\right) - (1-p_M)\, L + \pi_F\left(h^C_F\right)\left(\Phi^C_M + \Phi^C_F\right) - \lambda d^C_M\right] \\ - (\mu_M + \alpha\mu_F)\left[u\left(d^C_M\right) - (1-p_M)\, L\right] \\ - \left[\mu_F\left(\Phi^c_F + \alpha\Phi^c_M\right) + \mu_M\left(\Phi^c_M + \alpha\Phi^c_F\right)\right]\pi_F\left(h^C_F\right) \end{array}\right] = \lambda(1+\bar{\alpha})n^C \tag{57}$$

$$\pi_F{}'\left(h^C_F\right)\left[\begin{array}{l} (1+\bar{\alpha})\, n^C \left[u\left(d^C_F\right) - (1-p_F)\, L + \pi_M\left(h^C_M\right)\left(\Phi^C_M + \Phi^C_F\right) - \lambda d^C_F\right] \\ - (\mu_F + \alpha\mu_M)\left[u\left(d^C_F\right) - (1-p_F)\, L\right] \\ - \left[\mu_F\left(\Phi^c_F + \alpha\Phi^c_M\right) + \mu_M\left(\Phi^c_M + \alpha\Phi^c_F\right)\right]\pi_M\left(h^C_M\right) \end{array}\right] = \lambda(1+\bar{\alpha})n^C \tag{58}$$

Let us rewrite the above equations assuming that $\alpha = 1$:

$$u'\left(c^C_M\right) = u'\left(d^C_M\right) = u'\left(c^C_F\right) = u'\left(d^C_F\right) = \frac{\lambda(1+\bar{\alpha})n^C}{(1+\bar{\alpha})n^C - (\mu_M + \mu_F)}$$

$$\pi_M{}'\left(h^C_M\right)\left[\begin{array}{l} (1+\bar{\alpha})\, n^C \left[u\left(d^C_M\right) - (1-p_M)\, L + \pi_F\left(h^C_F\right)\left(\Phi^C_M + \Phi^C_F\right) - \lambda d^C_M\right] \\ - (\mu_M + \mu_F)\left[u\left(d^C_M\right) - (1-p_M)\, L\right] \\ - \left[\mu_F\left(\Phi^c_F + \Phi^c_M\right) + \mu_M\left(\Phi^c_M + \Phi^c_F\right)\right]\pi_F\left(h^C_F\right) \end{array}\right] = \lambda(1+\bar{\alpha})n^C$$

$$\pi_F{}'\left(h^C_F\right)\left[\begin{array}{l} (1+\bar{\alpha})\, n^C \left[u\left(d^C_F\right) - (1-p_F)\, L + \pi_M\left(h^C_M\right)\left(\Phi^C_M + \Phi^C_F\right) - \lambda d^C_F\right] \\ - (\mu_F + \mu_M)\left[u\left(d^C_F\right) - (1-p_F)\, L\right] \\ - \left[\mu_F\left(\Phi^c_F + \Phi^c_M\right) + \mu_M\left(\Phi^c_M + \Phi^c_F\right)\right]\pi_M\left(h^C_M\right) \end{array}\right] = \lambda(1+\bar{\alpha})n^C$$

From the first line, we obtain (28). After some rearrangements of the last two lines, we obtain (29) and (30).

9.3.2 Decentralised problem

Comparing (12) and (14) with (51), (52), (55) and (56), we find that $\tau_F^c = \tau_M^c = \tau_F^C = \tau_M^C = 0$. We find θ_M^c and θ_F^c by comparing (13) and (14) with (53) and (54). After some rearrangements, we obtain

$$\begin{aligned}
\theta_M^c &= \frac{\pi_M'\left(h_M^c\right)\pi_F\left(h_F^c\right)}{u'\left(c_M^c\right)}\Phi_F^c\left[\frac{(1+\bar{\alpha})\,n^c\,(\alpha-1)+\left(\alpha^2-1\right)\mu_F}{(1+\bar{\alpha})\,n^c+(\mu_M+\alpha\mu_F)}\right]<0\\
\theta_F^c &= \frac{\pi_F'\left(h_F^c\right)\pi_M\left(h_M^c\right)}{u'\left(c_F^c\right)}\Phi_M^c\left[\frac{(1+\bar{\alpha})\,n^c\,(\alpha-1)+\left(\alpha^2-1\right)\mu_M}{(1+\bar{\alpha})\,n^c+(\mu_F+\alpha\mu_M)}\right]<0
\end{aligned}$$

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

We obtain θ_M^C and θ_F^C by comparing (13) and (14) with (57) and (58). After some rearrangements, we obtain

$$\begin{aligned}
\theta_M^C &= \frac{\pi_M'\left(h_M^C\right)\pi_F\left(h_F^C\right)}{u'\left(c_M^C\right)}\times\frac{1}{(1+\bar{\alpha})\,n^C-(\mu_M+\alpha\mu_F)}\\
&\quad\times\left[\begin{array}{l}(1+\bar{\alpha})\,n^C\,(\alpha-1)\,\Phi_F^C+\mu_M\left(\Phi_M^c-\Phi_M^C+\alpha\left(\Phi_F^c-\Phi_F^C\right)\right)\\ +\mu_F\left(\alpha\left(\Phi_M^c-\Phi_M^C\right)+\Phi_F^c-\alpha^2\Phi_F^C\right)\end{array}\right]\\
\theta_F^C &= \frac{\pi_F'\left(h_F^C\right)\pi_M\left(h_M^C\right)}{u'\left(c_F^C\right)}\times\frac{1}{(1+\bar{\alpha})\,n^C-(\mu_F+\alpha\mu_M)}\\
&\quad\times\left[\begin{array}{l}(1+\bar{\alpha})\,n^C\,(\alpha-1)\,\Phi_M^C+\mu_F\left(\Phi_F^c-\Phi_F^C+\alpha\left(\Phi_M^c-\Phi_M^C\right)\right)\\ +\mu_M\left(\alpha\left(\Phi_F^c-\Phi_F^C\right)+\Phi_M^c-\alpha^2\Phi_M^C\right)\end{array}\right]
\end{aligned}$$

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

9.4 Cooperative household model

9.4.1 Laissez-faire problem

The Lagrangian of problem C is

$$\begin{aligned}
\pounds\left(c_M^{kj},d_M^{kj},h_M^{kj},c_F^{kj},d_F^{kj},h_F^{kj}\right) &= \eta\left[\begin{array}{l}U_M\left(c_M^{kj},d_M^{kj},h_M^{kj}\right)+\pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_M^j\\ +\alpha^k\left[U_F\left(c_F^{kj},d_F^{kj},h_F^{kj}\right)+\pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j\right]\end{array}\right]\\
&\quad+(1-\eta)\left[\begin{array}{l}U_F\left(c_F^{kj},d_F^{kj},h_F^{kj}\right)+\pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_F^j\\ +\alpha^k\left[U_M\left(c_M^{kj},d_M^{kj},h_M^{kj}\right)+\pi_M\left(h_M^{kj}\right)\pi_F\left(h_F^{kj}\right)\Phi_M^j\right]\end{array}\right]\\
&\quad+\lambda\left[2w-c_M^{kj}-h_M^{kj}-\pi_M\left(h_M^{kj}\right)d_M^{kj}-c_F^{kj}-h_F^{kj}-\pi_F\left(h_F^{kj}\right)d_F^{kj}\right]
\end{aligned}$$

which yields the following first-order conditions:

$$\begin{aligned}
\left[\eta\alpha^k + (1-\eta)\right] u'\left(c_F^{kj}\right) &= \lambda \\
\left[\eta + (1-\eta)\,\alpha^k\right] u'\left(c_M^{kj}\right) &= \lambda \\
\left[\eta\alpha^k + (1-\eta)\right] u'\left(d_F^{kj}\right) &= \lambda \\
\left[\eta + (1-\eta)\,\alpha^k\right] u'\left(d_M^{kj}\right) &= \lambda \\
\pi'_M\left(h_M^{kj}\right)\left[\begin{array}{l} \left(\eta + (1-\eta)\,\alpha^k\right)\left[u\left(d_M^{kj}\right) - (1-p_M)\,L\right] - \lambda d_M^{kj} \\ +\pi_F\left(h_F^{kj}\right)\left(\eta\left(\Phi_M^j + \alpha^k\Phi_F^j\right) + (1-\eta)\left(\Phi_F^j + \alpha^k\Phi_M^j\right)\right) \end{array}\right] &= \lambda \\
\pi'_F\left(h_F^{kj}\right)\left[\begin{array}{l} \left(\eta\alpha^k + (1-\eta)\right)\left[u\left(d_F^{kj}\right) - (1-p_F)\,L\right] - \lambda d_F^{kj} \\ +\pi_M\left(h_M^{kj}\right)\left(\eta\left(\Phi_M^j + \alpha^k\Phi_F^j\right) + (1-\eta)\left(\Phi_F^j + \alpha^k\Phi_M^j\right)\right) \end{array}\right] &= \lambda
\end{aligned}$$

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 $(40) - (43)$.

9.4.2 Decentralised first-best allocation

The decentralised problem of a couple is

$$\begin{aligned}
&\max_{\substack{c_M^{kj}, c_F^{kj}, d_M^{kj}, \\ d_F^{kj}, h_M^{kj}, h_F^{kj}}} \eta\, V_M^{kj}\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)\Big|_{\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)} + (1-\eta)\, V_F^{kj}\left(c_F^{kj}, d_F^{kj}, h_F^{kj}\right)\Big|_{\left(c_M^{kj}, d_M^{kj}, h_M^{kj}\right)} \\
&\text{s.to } 2w - \Big[c_M^{kj} + h_M^{kj}\left(1+\theta_M^{kj}\right) + \pi_M\left(h_M^{kj}\right) d_M^{kj}\left(1+\tau_M^{kj}\right) \\
&\quad + c_F^{kj} + h_F^{kj}\left(1+\theta_F^{kj}\right) + \pi_F\left(h_F^{kj}\right) d_F^{kj}\left(1+\tau_F^{kj}\right) + T^{kj}\Big] \geq 0
\end{aligned}$$

where τ_i^{kj} and θ_i^{kj} are taxes on savings and on prevention for a type-i agent belonging to a couple (k,j) and T^{kj} are lump-sum transfers given to a couple (k,j). Rearranged first-order conditions are thus

$$\begin{aligned}
\frac{u'\left(d_F^{kj}\right)}{u'\left(c_F^{kj}\right)} &= \left(1+\tau_F^{kj}\right) \\
\frac{u'\left(d_M^{kj}\right)}{u'\left(c_M^{kj}\right)} &= \left(1+\tau_M^{kj}\right) \\
\pi'_M\left(h_M^{kj}\right)\left[\begin{array}{r} u\left(d_M^{kj}\right) - (1-p_M)\,L - u'\left(d_M^{kj}\right) d_M^{kj} \\ +\pi_F\left(h_F^{kj}\right)\left(\Phi_M^j + \Phi_F^j\frac{\eta\alpha^k+(1-\eta)}{\eta+(1-\eta)\alpha^k}\right) \end{array}\right] &= u'\left(c_M^{kj}\right)\left(1+\theta_M^{kj}\right) \\
\pi'_F\left(h_F^{kj}\right)\left[\begin{array}{r} u\left(d_F^{kj}\right) - (1-p_F)\,L - u'\left(d_F^{kj}\right) d_F^{kj} \\ +\pi_M\left(h_M^{kj}\right)\left(\Phi_F^j + \frac{\eta+(1-\eta)\alpha^k}{\eta\alpha^k+(1-\eta)}\Phi_M^j\right) \end{array}\right] &= u'\left(c_F^{kj}\right)\left(1+\theta_F^{kj}\right)
\end{aligned}$$

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