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# How much risk is mitigated by LTC Insurance? A case study of the public system in Spain

Montserrat Guillen (RFA-IREA)
Adelina Comas-Herrera

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Montserrat Guillén
Dept. of Econometrics, RISC-IREA, University of Barcelona
Adelina Comas-Herrera
PSSRU, LSE Health and Social Care London School of Economics and Political Science

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# 1 Introduction and motivation

One of the main objectives of Long-Term Care projection schemes, public and private, is to mitigate the risk to individuals of being exposed to “catastrophic” costs of care (see, for example, OECD, 2011), which can occur when a person needs care for a very long period of time.

The effectiveness of LTC protection schemes as risk transfer instruments has received little attention in the literature. It is difficult to compare existing alternative LTC protection strategies, especially for elaborating international correspondences because each country has very specific regulations (see for example Taleyson, 2003).

This paper discusses risk measures that are well-known in insurance and financial economics and their potential use for comparing the effectiveness of LTC protection systems as risk transfer instruments. Risk measurement is essentially aimed at evaluating both the likelihood that a loss occurs and the magnitude of this loss. We will propose a method to assess how much risk is mitigated by a LTC protection system that would otherwise be born

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by individuals or their families. Quantitative risk measurement relies on statistical concepts and provides tools to obtain a numerical value that represents the risk level of a potential loss.

In general, risk mitigation finds ways to reduce risk and when addressing economic losses, the simplest way to mitigate risk is to transfer it to someone else, who would cover the cost if the loss occurs in exchange of a premium. Risk transfer is also easily achieved by sharing the risk with other individuals that also have the possibility that a loss occurs to them. Therefore, in our situation, the way to mitigate the risk that an individual has to spend an enormous amount of money during his or her lifetime is to subscribe to a LTC coverage protection scheme that would share the expenditure among participants in the programme. LTC coverage can take many different forms, ranging from contribution to a national public LTC system through general or local taxation, to social insurance contributions, to individual or group purchased private insurance. In practice in most countries public and private LTC coverage protection systems coexist and complement each other to different degrees (see, for example, OECD, 2011).

Formal definitions of risk measures are available and their mathematical properties have been studied in the context of risk management, actuarial science and finance (see, for instance, McNeil et al. 2005, Denuit et al. 2005, Coles, 2001, Panjer, 2006, Panjer et al. 2008). Our contribution is to adapt these measures to the analysis and comparison of LTC protection schemes. It is assumed that lifetime LTC costs can be seen as an economic loss which is a random variable Risk assessment requires that an estimate of the statistical distribution of the loss is available. In the rest of this paper, our loss random variable is the lifetime cost of LTC.

We do not analyse here other statistical measures such as the Gini coefficient which could be implemented to measure inequality and would be useful to examine the concentration of LTC costs and its variability across a population age group. In order to assess the effectiveness of a protection scheme as a mechanism to transfer and share risk, what we need is a measure of risk mitigation, that is, the ability of the programmes to reduce the risk born by individuals.

## 2 Notation and basic concepts

We denote by $X_0$ the lifetime cost of LTC from a given age $t$ to death assuming that there is no level of protection so that the individual has to pay for all the costs of services aimed at his or her care. At age $t$ the value of $X_0$ is unknown mainly due to the uncertainty about the probability of needing care, its duration and the inflation of the cost of services. Note that there will also be changes in risk factors and treatments that will have an impact on the evolution of disability rates. So, we can assume that $X_0$ is a random variable which follows a probability distribution with a probability distribution function $F_0(x)$, for $x \geq 0$, defined as the probability that the lifetime cost of LTC from age $t$ is not larger than $x$.

We will assume $X_p$ is the cost of lifetime LTC for an individual at age $t$ if he or she is covered by a public system or subscribes to a voluntary protection plan so that part (or all) of the cost of LTC in $X_0$ is covered by an insurance scheme, either private or public or both. Indeed the state can propose a universal coverage system, for instance. In that case the final value of $X_p$ is also unknown to the person at age $t$, and it will only become known once the person dies. At age $t$, $X_p$ is a random variable which follows a probability distribution function $F_p(x)$, $x \geq 0$ which is the probability that the lifetime cost of LTC not covered by the external protection is smaller than $x$.

For any given random variable we can define risk measures that can be used to evaluate its level of risk. We aim at quantifying the risk transfered from $X_0$ to the protection scheme, that is from the individual to the insurance plan or the public protection programme (or both). One simple way to do that is by comparing the distribution of $X_0$ and $X_p$ or their respective risk measures.

## 3 The Value-at-Risk of LTC lifetime individual expenditure

The first measure we will discuss, RM1, assesses how much an LTC protection scheme will protect those in the quantiles facing the highest lifetime costs of care.

Assume we fix a probability level $\alpha_0$, $\alpha_0 \in (0,1)$. It means we are only considering the cost of LTC that is incurred by the $\alpha_0 100\%$ of the population that is going to spend more money on LTC. It means we are interested in the worst cases, those who face the highest lifetime costs.

The notion *Value-at-Risk* with level $\alpha_0$ is related to the notion of quantile and is defined as follows:

$$\mathrm{VaR}_{\alpha_0}\left(\mathrm{X_j}\right)=\inf\left\{\mathrm{x}, \mathrm{F_j}(\mathrm{x})\geq\alpha_0\right\}, \quad \text{for } j=0 \text{ or } j=p. \tag{1}$$

The interpretation for the Value-at-Risk at level $\alpha_0$ of individual lifetime LTC cost under protection scheme $j$, $j$=0 or $j$=$p$ is straightforward. There is $(1-\alpha_0)100\%$ of the population aged $t$ that spends at least $\mathrm{VaR}_{\alpha_0}(\mathrm{X_0})$ if there is no protection and at least $\mathrm{VaR}_{\alpha_0}\left(\mathrm{X_p}\right)$ if protection $p$ covers him or her. Another way to interpret Value-at-Risk is that a $\alpha_0 100\%$ percent of the population aged $t$ spends less than $\mathrm{VaR}_{\alpha_0}(\mathrm{X_0})$ if there is no protection but less than $\mathrm{VaR}_{\alpha_0}\left(\mathrm{X_p}\right)$ under protection $p$. All the previous interpretations do have to be considered in the context of a probability space. They have been widely used for assessing financial risk (Jorion, 2001, Klüppelberg et al., 1999). Note that $\alpha_0$ is often called the confidence level and $(1-\alpha_0)$ is known as the risk level.

We will define the amount of risk mitigation of policy $p$, with respect to the scenario where the whole burden is on the individual, based on the concept of Value-at-Risk as:

$$RM_1(\alpha_0; 0; p) = \mathrm{VaR}_{\alpha_0}(\mathrm{X_0})\text{-}\mathrm{VaR}_{\alpha_0}\left(\mathrm{X_p}\right) \tag{2}$$

The main drawback of $RM_1(\alpha_0; 0; p)$ is that there must be a consensus on which is the $\alpha_0$ level (or quantile) that is going to be chosen for comparative purposes.

Once $\alpha_0$ is fixed, $RM_1(\alpha_0; 0; p)$ can be computed for several protection alternatives $p$ and one can say that a policy is more effective than another if it has larger risk mitigation.

# 4 Conditional tail expectation or Tail-Value-at-Risk of LTC lifetime individual expenditure

If we would like to average values at risk with respect to different $\alpha$ levels, then we can use the notion of *Tail-Value-at-Risk* at level $\alpha_0$. Let us assume that $\alpha_0$, $\alpha_0 \in (0,1)$ is a fixed confidence level. We would like to examine all Value-at-Risk at levels between $\alpha_0$ and 1.

The definition of *Tail-Value-at-Risk* with a given level probability $\alpha_0$ is:

$$TVaR_{\alpha_0}(X_j) = \frac{1}{(1-\alpha_0)} \int_{\alpha_0}^{1} VaR_{\alpha}(X_j) d\alpha, \quad \text{for } j=0 \text{ or } j=p.$$

The previous definition is mathematically equivalent, under adequate sufficient smoothness conditions for the distribution function of $X_j$, $j$=0,$p$, to a conditional expectation:

$$TVaR_{\alpha_0}(X_j) = E\left(X_j \middle| X_j > VaR_{\alpha_0}(X_j)\right), \quad \text{for } j=0 \text{ or } j=p. \tag{3}$$

where $E$ denotes the mathematical expectation as usual.

The Tail-Value-at-Risk can be interpreted as an average for all Value-at-Risk cases above a level $\alpha_0$. In our case, it is the expected value of lifetime LTC costs with no protection ($X_0$) or with protection ($X_p$) for the $(1-\alpha_0)100\%$ group of individuals aged $t$ who will experience costs larger than $VaR_{\alpha_0}(X_j)$, for $j$=0 or $j$=$p$ respectively. So, it concentrates on the average cost for the group that will incur larger costs.

Note that there are many possible ways to fix the value of $\alpha_0$. For instance, one may say that $\alpha_0$=75% and that would imply that $TVaR_{\alpha_0}(X_j)$ corresponds to the average cost incurred in the group that exceeds the 75% percentile cost.

An interesting way to fix the value of $\alpha_0$ is somehow indirectly. Let us assume that we define $\alpha_0$ as the level such that $F_0(x_0)= \alpha_0$ given that $x_0$ is a fixed amount. In this case $(1-\alpha_0)100\%$ is defined as the percent of individuals aged $t$ that would face lifetime LTC costs above $x_0$. The value of $x_0$ could be fixed with respect to a yearly minimum income level. It can also be fixed in absolute terms. Then $TVaR_{\alpha_0}(X_0)$ would be interpreted as the average lifetime LTC cost incurred by for those who would pay a lifetime LTC cost greater than $x_0$.

Note that if $\alpha_0$=0 the Tail-Value-at-Risk is the expected lifetime LTC cost, on average, of all individuals in the population.

We will define the amount of risk mitigation of policy $p$ with respect to policy 0, $RM_2(\alpha;0;p)$, using the concept of Tail-Value-at-Risk as:

$$RM_2(\alpha_0;0;p) = TVaR_{\alpha_0}(X_0)\text{-}TVaR_{\alpha_0}(X_p) \tag{4}$$

In order to compute $RM_2(\alpha_0;0;p)$ first we need to choose a level for $\alpha_0$. Once $\alpha_0$ is fixed, $RM_2(\alpha_0;0;p)$ can be calculated for several protection alternatives $p$ and one can score alternatives with respect to the gain in risk mitigation.

The main drawback of the comparative capacity of $RM_2(\alpha_0;0;p)$ for alternative $p$ policies is that the comparison is made between the distribution for those facing the highest cost only.

However, calculating $RM_2(\alpha_0;0;p)$ is simple, once estimates of the distribution functions of $X_0$ and $X_p$ are available. Moreover, $RM_2(\alpha_0;0;p)$ can be interpreted as the average LTC cost that is covered by the protection scheme for the catastrophic group, i.e. for those individuals that incur the highest costs.

It is interesting to note that $TVaR_{\alpha_0}(X_j)$ at a given level is a coherent risk measure that has been used in many areas. It has risen independently in a variety of fields and has been given names as *Conditional Value-at-risk*, *Conditional Tail Expectation* or *Expected Shortfall* (see Duffie and Pan, 1997; Artzner et al., 1999 and Denuit et al. 2005). It satisfies the so-called axioms of coherence, namely translation invariance, subadditivity, positive homogeneity and monotonicity. In particular, subadditivity means that if lifetime LTC costs are calculated as the sum of types of costs, the Tail-Value-at-Risk with level $\alpha_0$ of the total cost is smaller or equal than the sum of the Tail-Value-at-Risk with level $\alpha_0$ of each type of cost.

# 5 Using Tail-Value-at-Risk to rank alternative social policies

The final measure we discuss, RM3 measures how much an LTC protection scheme reduces the average lifetime cost of care for those in the quantiles facing the highest costs. We will call this measure the *relative risk mitigation index*.

Let us assume that $X_0$ is the cost of lifetime long term care (LTC) from a given age $t$ to death assuming that there is no level of protection so that the individual has to pay for all costs aimed at his or her care. $X_0$ is a random variable which follows a probability distribution function $F_0(x)$, $x \geq 0$. This can be called the *reference cost distribution*. Let us also assume that there are programmes that aim at reducing the risk of incurring very large lifetime costs by means of a risk transfer. We will call the lifetime LTC costs that would be paid if each of these alternative programmes are implemented, $X_p$ with $p=1,2,\ldots,P$, and their corresponding distribution functions are called $F_p$ $p=1,2,\ldots,P$. We assume that the Tail-Value-at-Risk at a given level $\alpha_0$ for those distribution functions can be estimated.

We can define a percent reduction of the Tail-Value-at-Risk at level $\alpha_0$, which we call the *relative risk mitigation index* as:

$$RM_3(\alpha_0;0;p) = \left(1 - \frac{TVaR_{\alpha_0}(X_p)}{TVaR_{\alpha_0}(X_0)}\right) \cdot 100 \tag{5}$$

Assuming that costs incurred are always positive and that $X_p \leq X_0$ almost surely in probability terms, which means that the probability that $X_p$ is larger than $X_0$ is zero then it can be shown that $RM_3(\alpha_0; 0; p)$ is a score between zero and 100.

A technical difficulty in the comparison of $X_0$ and $X_p$ is that there is no guarantee that the probability of $X_0$ equals 0 is the same as the probability that $X_p$ equals 0. Individuals may incur cost if there is no protection programme, while they may have to pay nothing when $p$ is implemented. The fact that $X_0$ and $X_p$, $p$=1,..,$P$ have a positive probability mass on 0, possibly not constant across all these random variables poses a potential technical problem, because rankings may then depend on the selected $\alpha_0$ level.

# 6 An example and computing tools

Let us compare two random variables $X_0$ and $X_1$ whose probability distribution functions are known. We have simulated lognormal data to have a shape similar to the one we would expect in an application to lifetime LTC costs. This is an example that helps to introduce the application of the relative risk mitigation index which has been introduced in the previous section.

Figure 1 shows the Value-at-Risk plot, which is also known as the quantile plot. One can see from the shapes that for all possible levels Value-at Risk is always lower for $X_0$ than for $X_1$.

Table 1 presents the Value-at-Risk in the simulated data for three $\alpha_0$ levels. We have chosen $\alpha_0$=0.85, 0.90 and 0.95. Tail-Value-at-Risk at those same levels are also shown. The larger the $\alpha_0$ level is, the higher the estimated value. This means Value-at-Risk increases when the confidence parameter increases, as expected. The same happens as Tail-Value-at-Risk increases when $\alpha_0$ increases, because the measure concentrates on the most extreme cases.

Using both Value-at-Risk and Tail-Value-at-Risk we see that risk mitigation occurs when comparing $X_0$ versus $X_1$. For all three levels chosen, the risk of $X_1$ is lower than the risk of $X_0$, consequently $RM_1$ and $RM_2$ are positive for all values of $\alpha_0$.

The calculation of $RM_3$ for $\alpha_0$=0.85, 0.90 and 0.95 is also presented in the last column of Table 1. The relative risk mitigation index for $X_1$ compared to $X_0$ is about 55% for all confidence levels in this example.

Table 1: Risk measures and risk mitigation measures for simulated data ($X_0$ and $X_1$)

| | Value-at-Risk | | Tail-Value-at-Risk | | | | |
|---|---|---|---|---|---|---|---|
| Level ($\alpha_0$) | $\mathrm{VaR}_{\alpha_0}(X_0)$ | $\mathrm{VaR}_{\alpha_0}(X_1)$ | $\mathrm{TVaR}_{\alpha_0}(X_0)$ | $\mathrm{TVaR}_{\alpha_0}(X_1)$ | $RM_1$ | $RM_2$ | $RM_3$(%) |
| 85% | 7.44 | 3.82 | 13.11 | 6.06 | 3.62 | 7.05 | 54% |
| 90% | 9.37 | 4.62 | 15.42 | 6.96 | 4.75 | 8.46 | 55% |
| 95% | 12.99 | 6.07 | 19.51 | 8.50 | 6.92 | 11.01 | 56% |

$RM_1$ indicates the difference in Value-at-Risk, $RM_2$ is the difference in Tail-Value-at-Risk and $RM_3$ is the relative difference in Tail-Value-at-Risk

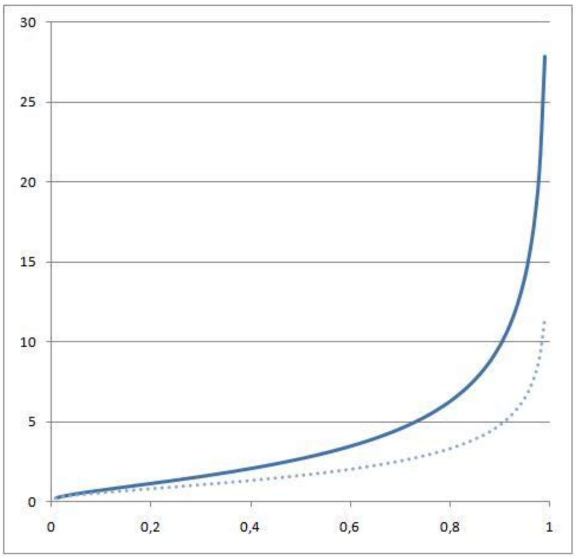


Figure 1: Value-at-risk for $X_0$ (solid) and $X_1$ (dotted), horizontal axis is α for simulated lognormal data

## 7 A case study: The public LTC system in Spain

In December 2006 the Spanish parliament approved the Law of Dependence, which was enforced in 2007. The law established a public long-term care (LTC) system and granted new rights to citizens in need of personal assistance. The law was recognized as a fourth pillar to the Spanish welfare system. Since then, the Spanish general budget has assigned increasing levels of funds for citizens needing LTC, and those funds have been set independently of public health funds.

The Law of Dependence in Spain provides support for all individuals from age 6, but elderly citizens are in fact much more prone to need some form of long term care. The natural demographic evolution in Spain will cause a great increase in the number of individuals above age 65 in the next decades and therefore this will lead to an enormous potential increase in the number of people in need of care and support. Wittenberg et al. (2002), Guillén et al. (2007) and many others argue whether living longer necessarily means that individuals will have a longer active life or whether, on the average, elderly people will need support for a longer period of time in the near future. Bolance et al. (2010) found that for the Spanish case demand for LTC starts at a later age, but may last longer on average than in the past. The prospects of an increase in unit costs of service necessarily implies an increase in lifetime LTC cost for individuals. In addition, there are contributions to the discussion on the role of public and private LTC insurance by Brown and Finkelstein (2008, 2009), de Crasties (2009), Gleckman (2007) and Comas-Herrera et al. (2011).

The demographic situation in Spain generates concerns about the future levels of LTC expenditure. Before the recent law, several forms of social protection already existed in Spain. Public support was reserved for citizens with few economic resources, living alone and in need of LTC, but there was no entitlement to public LTC benefits. In practice, the public health system was effectively providing assistance to people in need of LTC who had scarce resources, but this created a burden for medical facilities and often resulted in an inefficient use of hospitals.

The new Spanish public system established an entitlement to public LTC in case of dependence. Emphasis is on care needs, not on disability or handicap. The budget allocated to social protection in Spain is among the lowest in Europe

The current Spanish LTC system is universal and funded by taxes. Entitlements are based on the severity of dependence and not on the individual’s wealth and income.

In 2010, there were 614,750 people receiving some form of allocation. In fact some people maybe receiving more than one benefit. 7,468 people got a prevention plan; 74,775 got tele-assistance; care at home was supplied to 78,968; a care at day or night centre unit was assigned to 39,312 users; residential care was provided to 114,263; supplementary service allocation was given to 50,803 people and supplementary cash allocation for family care was allowed to 357,599 Spanish citizens. Cash benefits for family care is by far the most popular form of support from the public system.

Bolancé, et al (2010) estimated the distribution function of lifetime LTC cost for men aged 65 who would be classified as dependent by the Spanish public system, using a large survey by the Spanish Statistical Institute in 2008. Respondents were classified as elligible or non-elligible by matching survey respondents to the levels of need that would trigger entitlement to public benefits. They were also rated in the official scale levels of severity. The same authors compared the distribution of lifetime LTC costs if no public entitlements were available and the distribution of lifetime LTC costs if the entitlements that are established by the Spanish regulation were applied, so that cost would be partially covered by the state. More details can be found in their report.

Table 2: Risk measures for lifetime LTC costs of dependence in Spain (2008) with and without the public system

| Men aged 65 | | | | | |
|---|---|---|---|---|---|
| | Value-at Risk | | Tail-Value-at Risk | | |
| Level | Without | With | Without | With | $RM_3$ |
| 90% | 111.8 | 84.9 | 220.1 | 141.8 | 36% |
| 95% | 210.9 | 136.9 | 277.7 | 175.4 | 37% |
| 99% | 314.6 | 211.8 | 330.6 | 229.4 | 31% |
| **Women aged 65** | | | | | |
| | Value-at Risk | | Tail-Value-at Risk | | |
| Level | Without | With | Without | With | $RM_3$ |
| 90% | 251.2 | 157.8 | 302.4 | 192.0 | 37% |
| 95% | 304.7 | 189.0 | 331.2 | 214.5 | 35% |
| 99% | 346.5 | 232.6 | 353.3 | 330.6 | 31% |

Cost is expressed in thousand Euros. Without the public protection costs are payed by individuals or their families and with the public system costs are partly covered by the state.

Table 2 presents the Value-at-Risk and the Tail-Value at Risk for three levels $\alpha_0$ which are equal to 90%, 95% and 99% and which correspond respectively to risk levels equal to 10%, 5% and 1% for the distribution of lifetime LTC cost of those aged 65 in 2008 in Spain. Two possibilities are considered: the estimated lifetime LTC cost distribution if individuals pay for all the services, i.e, without any public system coverage, and the distribution when the current public system covers some of the LTC cost

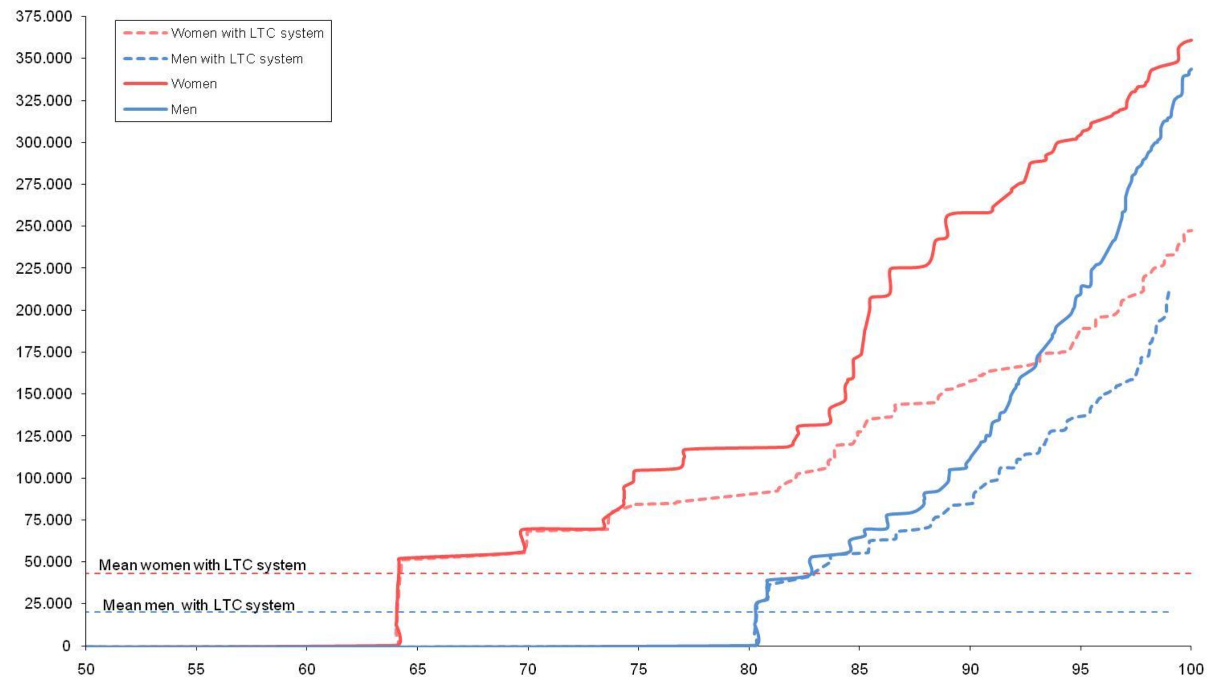


Figure 2: Value-at-risk of LTC costs of dependence in Spain for those aged 65 in 2008 with and without LTC public system, by gender

Our results show evidence that risk mitigation as defined in by $RM_3$ exceeds 30% both for men and women at any risk level. The interpretation then suggests that the public system reduces the risk of very high (or catastrophic) lifetime LTC cost. The implementation of the LTC public system guarantees that the highest or maximum possible cost incurred by the majority of the population (i.e. 90% or more) is reduced by more than 30% under the public LTC system.

By looking at the most extreme cases, the Tail-Value at Risk is also substantially reduced under the current public LTC system. In other words, the average cost for those people that would incur more expenses would be much reduced, especially if we look at the highest decile (90% level).

However, when looking into the details of Table 2 we conclude that the Spanish public system still needs to consider that there is a risk of about 1% that a man will have to spend about 229.4 thousand Euros and a risk of about 1% that a women will have to spend about 330.6 thousand Euros to cover lifetime LTC costs. This suggests that, despite the current public LTC coverage, risk mitigation may still seem too low for that small group who are continuing to face catastrophic costs of care.

If a major aim of the LTC system is to mitigate the risk to individuals of facing very high lifetime costs of care, policy makers may need to consider redesigning the way in which benefits are triggered so that account of taken of both the severity and the duration of care needs. Policy-makers could also consider providing or encouraging additional risk protection designed more specifically to help people who spend a very long period of time requiring care.

# 8 Discussion

Long-term care insurance either public mandatory or private plays a central role in financing long-term care (Feder et al., 2007). It is also a more efficient approach to covering lifetime expenditure than private savings, as it substantially reduces the need for every single individual or family to save up to the maximum possible lifetime cost of their care Insurance redistributes costs from those with lesser to those with greater care needs. By pooling risks and reducing the uncertainty risk averse individuals would prefer an actuarially fair insurance policy rather than the possibility of a substantial loss (see, for instance Barr, 2010, Browne, 2006, and Rivlin and Wiener, 1988).

Private long-term care insurance is always conditioned by the characteristics of public sector coverage for long-term care the specific country where an individual resides (Foubister et al., 2006, de Castries, 2009). In some countries like England or the United States, the public social policies aim at people who cannot afford to pay for their own care (Comas-Herrera et al., 2010, Miller et al., 2009). Those purchasing private insurance in those countries, because of the lack of a public coverage, tend to be offered private policies that aim to cover the totality of the costs of their care, which are largely unaffordable (Theisen Cramer and Jensen, 2005). In some other countries where the public LTC system is universal, all individuals are covered at least for part of their care. There may also be some means-tested benefits available for those who cannot cover the rest of their LTC costs. This is the case of Germany, France and Spain, where private LTC insurance tends to complement the public system (Comas-Herrera et al., 2011, Courbage and Roudaut, 2008, Guillén and Pinquet, 2008).

The risk mitigation index presented in this paper enables the assessment of how much protection is achieved by any one possible scheme at the individual sphere. Implementation of the method presented here requires that there exists an estimate the statistical distribution of lifetime LTC costs under the different scenarios that need to be compared. There are several approaches to obtain an estimate of the probability distribution function for a given population group, but choosing the best statistical approach among possible methods to obtain the distribution estimates depends substantially on the type of data that are available.

A final recommendation is to carefully check the technical hypothesis that are needed for the selected statistical approximation to the estimation of the distribution function of lifetime LTC costs. In the case study presented above there is no parametric assumption on the density shape of the random variable that represents lifetime costs, however several hypothesis were established before obtaining the distribution estimate. When calculating risk mitigation which requires the comparison of several distribution functions, hypothesis used to approximate those functions need to be consistent along the whole process.

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xreap@pcb.ub.es