PROFIT SHARING WITH THE LIFE INSURED AND SOLVENCY

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Abstract

Profit sharing of investment returns with the insured can take place through diverse procedures. On one hand, the firm guarantees the future behaviour of mortality and interest rate. On the other hand, the firm focuses on the efficient administration of the fund. All of them, including those of attenuated insurance, begin with a common formula that with certain modifications can provide us with different perspectives. During the first part of the report the author focuses in the different variations of the common formula and its main components. Towards the end of the report the author examines the different variations from a risk and solvency perspectives.

KEYWORDS: Life Insurance. Classic Life Insurance. Insurance with predetermined investments. Insurance with profit sharing. Unit-linked insurance. Universal Life Insurance. Life Insurance with defined claims. Solvency margin. Solvency II.

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1. Introduction

The insurance activity mainly consists of the coverage of risks that affect people or their patrimony, by means of a payment known as premium.

The main purpose of insurance companies is that premiums received from people exposed to a certain risk are sufficient for the payment of the claims, which affect not to all but a limited number of them.

On the other hand, the insurance contract establishes (is also a legal requirement) that the price, known as premium, has to be paid in advance by the insured.

Insurance is then a form of saving, organised by an insurance firm, in which some people exposed to the risk, assume collectively and under the "solidarity principle", the economic consequences derived from the event of risk occurring to some of them.

As premiums are paid in advance, it benefits from a process of financial capitalisation as insurance companies can invest the premium and obtain an investment return. For this reason, the company will have to make assumptions in order to calculate the premium, as well as it will have to anticipate the number of times that the risk will occur and the claim that will have to be satisfied in each case.

This way the insurer will consider, in order to calculate the premium, the probability that the event occurs and will discount the premium to the present by applying a predetermined interest rate. Furthermore, the company will need to consider for how long they can invest the premium as some claims will need to be satisfied. All in terms of "average values".

This is the traditional method used by insurance companies to look for the present value of future claims and future premiums.

Prediction of risk behaviour, as well as future investment returns, is based on the hypothesis that the behaviour of these variables can be based on past information, its tendency in time, whilst adding a "buffer" for negative changes in any of these variables. Furthermore, we assume that the future will remain more or less like the past and temporal series will remain fairly constant regarding the behaviour of the different variables considered in the actuarial calculations. In the short term, changes are unlikely but because life insurance is a long term contract chances are variable will not behave as initially predicted.

In fact, when the term of the policy is short, for example one year – the risk of error in the predictions is less than for longer periods of time. Therefore, the firm will be able to act in advance of the changes, despite the fact that the policy can be continued for additional periods of time – as it happens in most of non-life insurance or temporary insurance in case of death, annually renewable. Furthermore, in case the initial assumptions are not being fulfilled, it will be proposed the modification of the conditions of the contract, its premiums or sum assured, for subsequent periods.

But when the term of the policy is greater than a year, as it happens in many life insurance contracts -either for the coverage of the death, survival or retirement, the problem of the prediction of the behaviour of these variables becomes more difficult. Therefore, the insurance firm should be cautious to maintain its solvency margin.

For risks covering the existence of the human life, studied for centuries, for which a considerable statistical mathematical data has been gathered, still there is a high risk of statistical series being modified: phenomena like AIDS, or terrorism can truncate the progressively decreasing evolution of mortality rates. Or what it is even more possible, the advances in the genetic studies can allow a sudden jump in life expectancy.

The alternatives the insurance firm should consider regarding mortality and interest rate risk for long term contracts are:

- Either to continue maintaining the traditional approach of guaranteeing benefits in exchange for premiums without any possibility of changing the insurance contract, whilst reinforcing the solvency level.

- Or to establish the possibility of modifying the initial conditions to preserve solvency levels whilst improving administration of funds to increase investment returns.

This is the range of options, of which only two are attainable, in detriment of the third.

In this case the preferences of the insured refer to the following three objectives:

- To obtain the maximum investment return from its contributions
- To receive the agreed benefits in exchange for the premiums paid
- With the guarantee to reach them, that is to say, with the total insurer's solvency.

If maximum security and investment returns are pursued, the solvency is in doubt; if the aim is to secure and maximise solvency levels it could be at the cost of less investment returns; and if one looks for profitability and solvency it could be reached by decreasing the degree of security.

The approach of all types of life insurance contracts different from the classic type of contracts in which the criteria of securing and solvency prevail, consists of obtaining systems of attenuated insurance that allow to achieving an appropriate investment return at any given time whilst maximising solvency.

Let's take a look at the traditional approach of the subject and the possible solutions to the disadvantages that presents. In the last part, we will analyse the effects in the solvency margin for each type of insurance contract.

2. Insurance in the event of death and life: the traditional approach

Following what has been said until now, and making it specific to the insurance that covers the risk of human life, the insurance firm in the traditional approach should be able, as we have already stated, to carry out forecasts of the future behaviour of two variables: the mortality and the interest rate. The consequences of this approach for life insurance in case of death and those for survival are the following ones:

2.1. Insurance in the event of death

Price calculation or single premium for life insurance in case of death. The classic formula universally used, has been, in the case of a capital C' to be paid at the moment of the death of the insured, as is well known:

$$\Pi^{T}_{x,n} = C' \cdot \sum_{t=0}^{n-1} q_{x+t} \frac{1}{(1+r)^{t+1/2}}$$

In where C' is the sum assured, that we have established in capital form, q_x is the probability of death at the age x, r is the interest rate that the firm hopes to be able to obtain from the investments and n is the duration of the policy. We could use the formula in continuous time, in which the discount rate should be applied on the average period of probable duration of the premium, by the fraction of the same one not consumed at every moment, as an argument, the practical formula, in discreet time, is sufficiently illustrative.

In our case, we have simplified the model, because the validity of the reasoning does not vary for operations that are more complex. In the case of regular premiums, for different risk factors apart from the age of the insured, or for non constant sum assured or in form of profit, etc., although the risk for the insurer increases with regular premiums due to risk of reinvestment, and for annuities because of the guarantee of interest rate and mortality extends in time.

We need to acknowledge, for simplicity, that the distribution of deaths, at each age, is uniform, with for the maintenance average time of the investment of the premium is of half year if the death takes place in the first year of insurance. Of a year and half if, it takes place in the second, and so on and so forth, as it is expressed in the formula. Although, this hypothesis could be disputed, because the calculation could take place on the basis of the exact consumption of the premium in agreement with the Law of Mortality.

Note that we have indicated a constant r throughout all the term of the policy. It is because it is considered an average value. An alternative would be to anticipate growth or decrease in the time taking care of the temporary structure of the types of interest at the moment of contracting the policy.

In any case, what characterises the classic approach is the fact that an r and a q should be determined in an aprioristic form.

For the group of insured of the same age the insurance firm will collect, if we suppose all the capital uniform:

$$\sum_{M} \Pi_{x,n}^{T} = \sum_{M} C' \cdot \sum_{t=0}^{n-1} q_{x+t} \frac{1}{(1+r)^{t+1/2}}$$

This way of premium calculation assumes the possibility of estimation of mortality rates that will take place in the future. At each age or for each risk factor, as well as for the investment return the firm will obtain during the expected time in which they should not been consumed yet in the payment of the capitals insured in accordance with the Law of Mortality.

From an economic point of view, in the event of death of any insured, the firm has previously to standardise the sums insured in each policy, by means of, normally, the cession of the excesses of sums assured to reinsurance firms.

It is obvious that if the number of deaths coincides with the predicted and if the technical interest rate is reached exactly, the outcome of the firm, if the sums assured are homogenous, will be zero, being a loss or a benefit for the firm in case that real q y r are inferior and superior, respectively, to the predicted ones.

The saving that each person exposed to the risk deposited in the firm does not revert to the people who constituted it but it is assigned to pay the capital insured C', to each one of the policies in which the insured died.

The election of the q and the r to include in the formula for premium calculation is the most delicate decision that the insurance firm must adopt, because its sufficiency or insufficiency means the possibility or impossibility of the insurance company to satisfy claims.

Nevertheless, the insured pays the premium annually, either as a single or regular premium (with premiums increasing with mortality risk). Each one of these premiums will only stay in the company for, an average of, half a year, that is why the factor of discount applied in the premium is reduced, and the problem of predicting the interest rate practically becomes trivial with these policies.

However, the success or failure in the application of mortality risk can meet with great success in the firm if it has committed to pay benefits if the death takes place in the long term or even during the whole life. In the last decades, an increase in human longevity has occurred and consequently a reduction of mortality rates, but the firms, prudently, use mortality tables which have been developed to account for this factor.

In the last couple of years companies have chosen, as a result of the variability of interest rates and human mortality, to annually offer contracts of short duration with the possibility of modification of the technical basis of the policy for each period. The insurance, then, takes place every year, which guarantees the solvency of the firm, which, on the other hand and as a counterpoint, should offer competitive conditions to be able to maintain the confidence of the insured.

2.2. Insurance for case of life

In the case of survival policies, the premium that the insurance firm will request to each insured will be, in the traditional approach and for the simplest case of a policy of capital differed to a single premium:

$$\Pi_{x,n}^{D} = C \cdot {}_{n}p_{x} \cdot \frac{1}{(1+r)^{n}}$$

In where C is the benefit of the policy and ${}_{n}p_{x}$ is the probability of being alive after *n* years, complementary to probability of death. Here we also have to emphasize that we are showing the simplest operation but the reasoning is valid for the diverse variants that may occur: securing of annuities since the hypotheses on interest rates and survival must still be for a longer term --, regular payment of premiums, etc.

The insured, if alive after *n* years will receive:

$$C = \frac{\Pi_{x,n}^{D} \cdot (1+r)^{n}}{{}_{n}p_{x}} \qquad [1]$$

This is the balance formula that is applied in traditional insurance.

Like in insurance in the event of death, a rate of constant investment return for all the term of the policy is anticipated; although the model does not vary if it is extended to the case of variable investment returns related to a specific law of growth or decrease[1].

In this case, if the number of deaths every year, and consequently the number of survivors at the end of the predicted period of *n* years as well as the real interest rate agreed, the result of the operation will be zero for the insurance firm, making a profit in case that the real *q* and *r* are higher than the predicted ones.

Equally to what happens in the policies that cover risk of death, the saving that each person deposits in the insurance firm is only recovered after *n* years from the term of the contract by those who has survived, disappearing for the others. Consequently, there are restrictions in the possibility of repayment.

Nevertheless, it happens that the perception that exists on the part of the insured is not exactly the one that we have just described; since the operation of delayed capital insurance quite resembles one of pure financial deposit and it is confused with a process of individual capitalization, in which the saver would obtain by a deposit of $\Pi_{x,n}^{D}$ at the type of interest *r* during *n* years:

$$\Pi_{x,n}^{D} \cdot (1+r)^{n}$$

The capital C to perceive at the end of the policy for each insured is constituted by the three following components:

$$\Pi_{x,n}^{D} + \Pi_{x,n}^{D} \cdot r^{n} + C \cdot \sum_{t=0}^{n-1} q_{x+t}$$

That is to say, it is formed by the premium as first element, the financial yields corresponding to its financial capitalisation during *n* years secondly, and finally, by the part of the capital that “is left free” by the insured that is predicted to pass away in the term of duration of the policy. We have assumed that the capital to perceive in case of death is equal to the anticipated in case of survival.

Indeed, adding the three elements:

$$C \cdot {}_{n}p_{x} \cdot \frac{1}{(1+r)^{n}} + C \cdot {}_{n}p_{x} \cdot \frac{1}{(1+r)^{n}} \cdot r^{n} + C \cdot \sum_{t=0}^{n-1} q_{x+t} =$$

$$C \cdot {}_n p_x + C \cdot (1 - {}_n p_x) = C$$

In comparison with a system of individual saving, in which the saver wants to constitute a capital in n years, in this modality of policy the premium to satisfy to the insurance firm will be inferior, costs of management and interest being equal, because when foreseeing that all the insured will not arrive at the end of the term, the insurer only needs to constitute capital for the number of insured who the probability indicates that will survive.

In fact,

$$C \cdot \frac{1}{(1+r)^n} = C \cdot \frac{1}{(1+r)^n} \cdot ({}_n p_x + \sum_{t=0}^{n-1} q_{x+t}) =$$

$$C \cdot \frac{1}{(1+r)^n} \cdot {}_n p_x + C \cdot \frac{1}{(1+r)^n} \cdot \sum_{t=0}^{n-1} q_{x+t} =$$

$$= \Pi_{x,n}^{D} + C \cdot \frac{1}{(1+r)^n} \cdot \sum_{t=0}^{n-1} q_{x+t}$$

Therefore,

$$\Pi_{x,n}^{D} < C \cdot \frac{1}{(1+r)^n}$$

The difference between the quota of saving that will be deposited to financial capitalization with respect to the premium that will be necessary to obtain the same capital but by means of actuarial capitalization it will be therefore of:

$$C \cdot \sum_{t=0}^{n-1} q_{x+t} \cdot \frac{1}{(1+r)^n}$$

2.3. Mixed policies

In the general case of the insurance with sums assured in case of life and in case of death, maintaining as always the simplest case of mixed insurance with benefit C and C', respectively in case of life and in case of death, to unique premium, the balance equation will be, considering that:

$$\Pi_{x,n}^{M} = \Pi_{x,n}^{D} + \Pi_{x,n}^{T}$$

the following one:

$$C = \frac{(\Pi_{x,n}^{M} - \Pi_{x,n}^{T}) \cdot (1+r)^n}{{}_n p_x}$$

It is to say:

$$C = \frac{1}{{}_n p_x} \left[\Pi_{x,n}^{M} \cdot (1+r)^n - C' \cdot \sum_{t=0}^{n-1} q_{x+t} \cdot \frac{(1+r)^n}{(1+r)^{t+1/2}} \right]$$

$$= \frac{1}{{}_n p_x}\left[\Pi^{M}_{x,n}\cdot(1+r)^n - C'\cdot\sum_{t=0}^{n-1} q_{x+t}\cdot(1+r)^{n-t-1/2}\right]$$

[2]

This formula represents the general case of balance when guarantees of death and survival are included, simultaneously, in the contract. The firm capitalises the totality of the premium, with the exception of the part of the policy that covers the risk of death, adding to it the mortality factor.

In order to briefly complete this general vision of the traditional system of calculation of prices and equivalence of benefits, let's discuss briefly the methods used by firms to carry out the forecasts of the probability of death and their complementary one of survival, and of future interest rate.

3. Mortality Tables

In order to anticipate the behaviour of mortality –and consequently, of the survival as the opposite event -- firms apply a method of constructing mortality tables based on the experience of the general population or insured population, consciously weighted. That is to say, that they reflect behaviour of mortality worse than the one that presumably will take place in the future.

Thus for the calculation of premiums of death insurance, tables of historical mortality are used, which reflects the frequency of expected deaths to be less in the future, at different ages, given the progressive greater longevity of human life caused by social and health improvements.

However, for policies of survival the firms tend to use dynamic tables of mortality, which allow obtaining the hypothetical mortality that will take place in the coming generations on the projected basis, by means of statistical and mathematical techniques, the supported by the previous generations.

The initial basic hypotheses of the Theory of the Survival- homogeneity, that implies that the probability of death or survival only depends on the age. Independence, which supposes that interaction between individuals, does not exist. And stability, which implies that mortality, depends on the age but not on the calendar month -- they have been improved by the actuarial technique. At present time, other influential factors are considered, like gender or smoking, to mention only a few. Or the influence of the death of some individuals on the probability of survival of other[2], or the modification of the technical basis in group policies when the law of applied mortality is out of phase; or the introduction of the concept of dynamism in the mortality tables, already mentioned.

On the other hand, the use of different tables becomes necessary, for death and life, even in the mixed modalities that contain in the same policy that covers both risks.

4. The technical interest rate

In relation to the types of interest to discount in the formula of premium calculation, we have already said that the classic approach anticipates the fixation of a certain and constant rate for the term of the policy. If this is excessively cautious, the saver will prefer other alternatives for the investment of their saving; if they are excessively optimistic, will put in danger the solvency of the firm.

For many years after World War II interest rates were quite stable in western economies, with the exception of some countries with greater inflation[3] where their variability was greater,

reason why except in the latter traditional formulation of the operations of insurance stayed as apt for a long period.

In this classic approach, in addition to the basic aspect to establish the amount of *r*, the additional problem to solve is to guarantee the reinvestment of the flows of investment returns to the same or superior rate to which the premium has been calculated. This is solved by means of the construction of immunised portfolios of investment in view of to the risk of variation of the types of interest. If these are of fixed return, and since the variation in the types of interest has opposite effect in market values if the market is efficient, the immunisation is obtained by means of the equalisation of the horizon of the investment to the duration of the portfolio - weighted average term-- or by means of procedures of stochastic immunisation[4].

In order to immunise the global value of the portfolio of the firm, submissive to different expiry dates, different procedures exist. From the formulated by Redington in 1957, that establishes that the convexity of the firm assets should be greater than the one of the liabilities; until other models based on "term gap" formulated by Bierwag and Kaufman (1985), Bierwag (1987), Apple tree (1992), etc.[5]

However, the procedures of multiple immunisation, force the portfolio to be modify whenever the types of interest are modified, as new commitments with different terms arise. So that, the new portfolio is again immunised, which forces to a constant modification of the portfolio.[6] Another consideration is the difficulty that can arise when the behaviour of the short term is not parallel to the one on the long term, in which case the procedures of immunisation do not avoid certain risk of loss. Finally, we should not forget that the operations, contracted initially to be of *n* years old, can experience surrenders and lapses, so that the possibility of predicting turns into an essential point for the management of the investments.

On the other hand, the search for security in the investments prevents the positioning of the assets of the firm in other alternatives of investment. Like real assets, in equity, etc., which, by being used by other financial institutions that do not operate under the restriction of guaranteeing capital assets and interest, can allow to offer the expectation of profitability next to those of the market. On the understanding that this is in a wider sense than the exclusively referred to the one of fixed investment return.[7]

On the other hand, the stability of types of interest that continued in western economies during the decades of post-war period was followed by periods with greater variability of the types of interest. What has made difficult the decision on the quantity of the type of interest to apply in the calculation of the premiums when these are contracted in the long term, because excessively prudent interests could discourage the saver the same as excessively high types would jeopardize the stability of the insurance firm. This is why a wider analysis of the problem is necessary. The following sections will focus on this analysis.

5. Variations on the same subject: policies with predetermined investments and life insurance with profit sharing

In the previous section, we have shown the formulas [1] and [2] traditionally used by the insurers to determine equivalence between the premiums and the benefits in case of survival and have discussed succinctly the problems that arises.

The underlined problem is the rigidity of the elements of the same one:

$$C = \frac{\Pi_{x,n}^{D} \cdot (1+r)^n}{{}_n p_x}$$

or:

$$C = \frac{1}{{}_n p_x}\left[\Pi_{x,n}^{M} \cdot (1+r)^n - C' \cdot \sum_{t=0}^{n-1} q_{x+t} \cdot (1+r)^{n-t-1/2} \right]$$

For that reason we are going to analyse the consequences of introducing variations in each one of its components. At the moment we will maintain the *r*, but we will modify its meaning, to work on the other variables later.

5.1. If *r* happens to be the internal profit of a portfolio of investments: life insurance with predetermined investments

In the first place, we can consider valid the classic procedure, but altering the order of the decisions. Instead of establishing a priori the value of *r* we will fix it after acquiring a portfolio of investments. It means that the firm will have to constitute a first portfolio of investments and later go and look for investors who wish to place their savings to the type of interest that generates this investment and for a determined period of time.

The simplest procedure would consist of the acquisition of a package of investment coupon zero, to a determined expiry, with an internal rate of profitability *r*, which would be the type of technical interest in which the insurance would be offered. Another solution that is more complex would be the construction of a portfolio immunised to the risk of reinvestment, with equal expiries to those of the benefits. In both cases, we need to consider the need for predicting surrenders and therefore the risk inherent to its behaviour.

In both cases, the risk of the issuer, at the expense of the company, which introduces an undesirable element of uncertainty, and on the other hand, the system limits the profitability for the insured to the fixed return at the moment of contracting the policy. In addition, the company is exposed to the risk of surrenders in case of interest rates rising, which would leave it in possession of a devaluated portfolio.

5.2. Considering *r* as a provisional rate: life insurance with profit sharing

Still maintaining the traditional scheme, and therefore the repeated formulas [1] or [2] of balance between premiums and benefits, life insurance with profit sharing[8] consists of the allocation to the insured after having initially fixed a conservative and guaranteed *r* for the term of the contract, of positive differences of profitability obtained every year, fortuitously, by the insurance firm, above the technical interest rate.

Every year deviations will take place between the real survival and the predicted one, in other words with relation to the factor:

$$C \cdot \sum_{t=0}^{n-1} q_{x+t}$$

the difference between both of them can also revert to the insured through a procedure established in the policy.

In this case, what should be defined, in addition to the technical basis of mortality and technical interest *r*, is the quantity of the profit that will be provided to the insured, the form of distribution of the excess between the different policies and the form of allocation, by means of

cash, reduction of following premiums, increase of the insured capital or increase of the mathematical provision.[9]

This method can have two problems, one of them characteristic of its formulation and the other derivative of how it is actually executed: the profitability initially offered is conservative and for that reason it can be not very competitive and, in addition, the years of greater profitability with those of inferior profitability are not generally compensated, in other words it is not considered that *r* is an average value, but a minimum value of guaranteed annual profitability Nevertheless this second observation would not be applicable if the insurer establishes the contractual mechanisms to allow the indicated compensation in the years in which the real profitability is less than the predicted one.

A variation on the described system can consist of the annual allocation of a profit sharing communicated *ex ante* to the insured, by which the profitability to apply to the premiums is guaranteed and the mathematical provisions for the following year, running the company only with the risk of investment corresponding to this term.

6. A step forward towards the insurer's global solvency: Taking part in *C*

In the balance formula repeatedly mentioned, the risk of solvency of the insurer comes by the necessity to predict the future behaviour of *r*, reason why if it were possible to "eliminate" the same one, making *r* = 0, as a minimum the problem would be partially resolved, being left only the one of the prediction of mortality.

Adopting the null value for the type of technical interest, the formula [1], would be:

$$C = \frac{\Pi^{D}_{x,n}}{{}_{n}p_{x}}$$

In this case, *C* should be referred to a unit of account, different from the currency, which implicitly gathered the increase of value of the assets of investment at every moment.

Historically there have been experiences of life insurance related to indexed values, or based on the "formula of the "escape", consisting of referring the magnitudes of the insurance to the value of certain goods, like gold, that could gather the nominal increase of value derived from inflation.

But the suitable and organized instrument that allows using an account unit, to express $\Pi^{D}_{x,n}$ y *C*, and that implicitly gathers the market value of the capital assets and the obtained profits at every moment, is a movable investment fund.

6.1. Making *r* = 0: *unit linked* life insurance

The linked policies with variable investment funds, or *unit linked* consist basically, although multiple variants exist, in the investment of the saving component of the premium in units or participation of a fund, being the benefits of the linked insurance to the value of these units at the moment at which, by death or survival of the insured, they should be effective. For that reason, all the magnitudes of the insurance, as well as the mathematical provisions or the surrender values are referred to the value of these participations at every moment.

Although various types of insurances can occur, the common principle consists of the displacement of the risk of investment to the insured, who will receive as value of the benefits the one of the fund units at the moment at which these benefits are paid. Obviously, the firm should

choose to carry out the reference of the insurance the rates of investment funds that consider suitable to the insured's risk profile, for what it will allow them to participate in their election.

Life insurance linked with investment funds can be entirely or only partially linked, which occurs in the cases in which part of the insurance, continues being referred to the currency or when minimum guarantees are offered on capital and/or interest. Likewise, they can refer to the value of a sole investment fund or to the one of a basket of funds.

The problem of guaranteeing minimum benefits [11], when the insurance is totally linked, was studied by Benjamin (1966) and Squires (1974), on empirical evidence of the United Kingdom, as well as by the author (1977) in relation to Spain. This possible/fortuitous guarantee, in any case, should be limited to certain typologies of funds with reduced component of variable rent.

The types of policies that we are considering in this section allow the firm to offer the market profitability, linked to assets not only referred to fix rent but to other categories of investment; and if they are totally linked they eliminate completely the problem to decide technical interest rates. Nevertheless, they do not impinge on the problem to establish the probabilities of death or survival, since the same, should carry on being valued by the firm for all the term of the insurance.

6.2. Life Insurance linked to internal funds of appreciation

This modality of insurance was originally expressed by the author in 1981, in his work presented for the King Juan Carlos I Economy Award. Later in 1983 it was included in "El Seguro de Vida y la Depreciación Monetaria" published by Deusto.

The proposal of Pérez Torres, based on the study of the investments of the Spanish insurance firms from 1960 - 1980[12], consisted of the creation of a modality of life insurance related to the real profitability of an internal fund made up by an investment portfolio, copy of the structure of the market investments, with the restrictions applicable to insurance firms. It demonstrated that the real average market profitability of the assets in which the insurance firms could invest the mathematical provisions, for any period, offered a higher profitability than the obtained by the classic life insurance, affected by technical interest, the policies with profit-sharing and the linked funds.

The evolution of this idea, that awarded the author with the King Juan Carlos Economy Award, has been later absorbed by the market, with the policies linked to internally constituted investment portfolios by the firms, subdivided in units, with an analogous operation to the one of the policies linked with investment funds shown in the previous section.

7. Attacking by the side of the *n*

The real problem that presents the system to establish the equivalence between premiums and benefits that we have named traditional is the term of the operation. Consequently, if the operation of insurance is conceived as a succession of terms of a year or still shorter time, with the possibility in every term of modifying the technical basis of the insurance, most of the problem is solved. In addition, by this method not only the variability of the types of interest offered in every term can be set but also the possibility of modification of the mortality tables, to adjust them to which the firm considers appropriate at every moment, previously communicating each variation to the insured.

This it is the principle on which the life insurance called *universal life* is based. [12] In this case the premium of every year -or in general of every term in which the firm subdivides the insurance -- it is divided in two components of risk premium and saving premium, and the latter is capitalised to a variable rate of interest, being necessary, to be considered as an insurance

policy, that a minimum death component exists. For this reason, we will indicate the example of the mixed insurance.

The accumulated capital, in case of life, at the end of each policy annuity, will be obtained by the following recurrent method. We will suppose that the insured capital in the case of death in the year *t is* C_t', and that the type of interest offered by the firm in this period is r_t:

$$C_t = C_{t-1} + \frac{1}{{}_1p_{x+t}}\left[\Pi_t^M \cdot (1+r_t) - C_t' \cdot q_{x+t} \cdot (1+r_t)^{1/2}\right]$$

Therefore, it is a process of actuarial capitalisation of a year of duration prolonged for successive years at variable rates. And a renewable temporary death insurance in which the technical interest rates and the premium of the death insurance are modifiable in each term of insurance.

In addition, if the firm wishes to give right of surrender at any time and not only at the annual expiry of the policy (in this case, the firm will deduct the premium of the death insurance at the beginning of each year):

$$C_t = C_{t-1} + \Pi_t^M \cdot (1+r_t) - C_t' \cdot q_{x+t} \cdot (1+r_t)$$

Although in this case, the operation is only safe as far as the benefit in the case of death, because the accumulation of the saving premium takes place to financial capitalization. In the extreme situation in that the operation was subdivided in very short terms, for example daily, the *Universal Life* would become, in fact, a fund management operation.

The essential characteristics of a policy of this type are: its flexibility, that allows the modification of the insured benefits, of the amount of the premium and its regularity, as well as of the technical basis of the insurance; its transparency, since the insured knows the decomposition of the premium that takes place at every moment, the price of the death insurance and the interest rate that in every term is offered by the firm; and in the considered second case, the value of recovery is not restricted with arguments of anti selection since the provision in the case of life is obtained by means of a process of financial, not actuarial, capitalization.

The logical evolution of this exposition is the variable life insurance, which allows the insured to choose the type of investment in which their savings are placed.

In the market there are two types according to the form to determine the quantity of the sum assured in case of death: the modality A, in which the sum insured in case of death is the difference at every moment between the accumulated figure of saving and a capital previously agreed; or the modality B in which that refers to a percentage or additional quantity on the value of the saving accumulated. [13]

8. Allowing the modification of the value of $\Pi_{x,n}$

The conversion of the insurance in a fund management operation, the immediate step that is appropriate to include is constituted by the modalities of defined benefit, to which the desired provision is established, as well as the provisional premium; which can be modified in the future if the real results of profitability and mortality are different from the initially anticipated.

In certain cases, in which the provision of the insurance is linked to a number of initial unknown magnitudes, like for example, annual salary of the insured at the moment of their retirement, or the public benefits that they perceive from the social security, the insurance needs to be done on the basis of evolution of these magnitudes, and the policyholder commits to finance the complements of premium that are necessary to reach the established defined benefit.

In these cases, the operation of insurance can be based on traditional bases of guarantee of types of interest and mortality, or on the basis of the real value of the mathematical provisions at every moment, and of the calculation of the difference of provision in relation to what it has been established in the contract, for which the corresponding complementary premium should be provided. In case of excess, the firm would repay it to the payer.

In these cases, if the operation does not guarantee provisions not even the acquired with the premiums already perceived by the firm, the only financial risk that the insuring firm is responsible for is the volume of operations and surrenders.

This procedure of individual capitalization without guarantee is the one used for personal pension plans.

9. Participating in the sign = : Mutualisation of the benefits

As last assumption it would be possible to consider the rupture of the traditional formula of balance by the sign of the individual equality, although maintaining the equality between both terms of the formula of balance for the whole insured. In other words, it would be a question of participating in the formula modifying the equals sign by the one of inequality:

$$C \neq \frac{\Pi^{D}_{x,n} \cdot (1+r)^{n}}{{}_{n}p_{x}}$$

Although maintaining the balance at global level of the entire insured group:

$$\sum_{m} C = \sum_{m} \frac{\Pi^{D}_{x,n} \cdot (1+r)^{n}}{{}_{n}p_{x}}$$

That is to say, the benefits of the insurance would be determined based on the real results of the whole portfolio of the insured of the same age, of the same length/term. This exposition, implies a collective actuarial capitalization with real rates and real mortality which is not legally possible at private insurance level.

Throughout these notes, the different gradations of assumption of the risk on the part of the firm have been shown, from the traditional policies to the modalities in which the firm is dedicated more than to insure provisions, to administer assets. The efficiency of that administration will be the key point to evaluate if for the consumer the new modalities are better than the ones that guaranteed the benefits. Guarantee demands more prudence and more solvency requirements, which detract competitiveness and expectation of profitability; the administration allows assigning the profitability that the market offers, but leaves the taker exposed to the risk of investment.

10. The solvency of the insurer

The solvency or capacity to respond of its commitments of the insurance firm can refer to each specific operation or the whole of its operations. In the first case, the organization should establish the necessary technical and contractual specifications to guarantee the sufficiency of the premium in relation to the benefits of the insurance, which we have referred to, in the previous points. From the approach of traditional insurance with total guarantee, to the last modalities explained in which the firm limits itself to the efficient management of the assets that the insured have entrusted, we have pointed out the formulas used to preserve this individual solvency: security charge, reasonable election of mortality tables and in its case of technical interest rates,

contractual reserves for the later modification of the technical basis during the course of the policy, etc.

From the point of view of the solvency of the firm as a whole, there are two relevant magnitudes. On the one hand, the mathematical provisions constituted by the firm, as expression of the present value, at every moment, of the committed provisions and, secondly, the volume of own funds that guarantee the business continuity in case of deviations in the results.

As far as the first measurement of solvency, the mathematical provisions should be calculated by the prospective method in all the cases in that the interest rate and/or mortality, is guaranteed, since the retrospective reserve does not reflect the future commitments of the insurer. Except for the case in which the technical basis could be modified or the successive premiums in the future, if the contract allows this flexibility. In the insurances without guarantee of types of interest, however, the retrospective method or the cumulative one can be indicated.

The dynamic solvency margin, whose expression is the own funds of the firm, should also refer not only to the volume of operations of the firm[14] -- with the purpose of anticipating deviations that will be higher -- but also with the several risks that assume in their management as a firm.

The tendency of the studies on the subject goes towards the quantification of the real risk of each firm and to fix an appropriate solvency margin, instead of the effective present legal system, that establishes a fixed formula and excessively simple to quantify it.

Insurance firms should develop systems and models of control of their internal management to be able to evaluate the levels of own funds that are necessary based on the different risks that assume.

The requirement of own funds to the insurers is a double edge sword. On the one hand, it is good for the market that a high level of solvency is demanded to the firms; but the limit is the competitiveness. We have analyzed a similar problem in the first sections of this work. The protection of the consumers can be turned against them if they demand a very rigorous level of solvency to the insurance firms, because in that case the firm will lose competitiveness since they will destine increasing resources to the greater exigencies of own funds.

But, for that very reason, the possibility that each firm calculates its own margin of solvency in agreement with its management, instead of bowing to the general rules applicable to the whole sector, can be a form to free up own funds from the most efficient firms, and to reward the best managed, directing the totality of the sector towards better practices.

The present system of calculation of the solvency margin does not consider, for example, the market risk or the credit risk, neither the operational risk, nor the risk of investment.

We will expose next the risks that can affect the insurance life activity.

11. Classification of the risks that affect the insurance life activity

We can identify in the insurance activity a set of risks that affect it. Limiting the analysis to the life sector, a simple classification would be the following one:

Environmental Risks

We would indicate in this group the conditions of the social, demographic, economic environment, inflation, of industry legislation and other related sectors, the changes in the fiscal legislation, the evolution of the competitors, the appearance of new products in the market, etc. They in principle affect in the same way the insurers, although different protections could be distinguished as opposed to this type of risks based on the structures and strategies of each firm.

The risk of terrorism, phenomena of nature of catastrophic character and eventualities of this type could be included in this section.

Technical risks or of insurance

We would include in this section the underwriting process. Fraud prevention in the initial information, segmentation and selection of risks, the quality and prudence of the technical basis of interest and mortality used. The mechanisms of protection as opposed to the deviation that happened in the same ones in relation to the forecasts. The modalities of insurance, subject to greater or smaller risk in the fulfilment of these initial technical basis, the concentration or existence of risk accumulations, the policy of reinsurance, the level of sufficiency of the technical provisions at every moment, etc.

Risks of investment

We referred, on the one hand, to the risks of the financial market, like volatility, the temporary structure of the types of interest, exchange rate risk, situation in the economic cycle, etc.

And also of the risk assumed by the firm in its own investment policy: class and quality of the assets, risk of contribution, type of interest, reinvestment, risk of concentration/diversification, congruence of terms or ALM, is to say that, the movement of the liabilities can be transferred to the assets, and the risk of the issuer.

Finally, we would include the risk of liquidity that could be derived in case of recovery, by no possibility of accomplishment of investments or other exceptional assumptions.

Risks related to the operations

In this section it is possible to include a set of other risks, like the following ones:

- Risks in relation with the customers and suppliers. It is referred to the capacity of payment of the customers in the policies with periodic or divided payment, the real permanence of the policies in relation to the time for which they were contracted, the solvency of the reinsurance firms, risk derived from the intermediaries (agents and brokers).
- Risks related to means. They are referred to the possibility of fraud by fault of the systems of internal control, computer error, risk of staff rotation or lack of qualified staff, loss of opportunities by non-existence of resources, costs trend.
- Tax and legal risks, pending judicial matters.

Without undervaluing any of the exposed risks, it seems obvious that those of greater importance for a life insurance firm are those of subscription of risks, ALM and risk of interest, the risk of issuer and sufficiency of the technical provisions. In addition, the procedure of allocation of profitability which we have covered in this report.

12. Arrangement of the modalities of insurance according to the margin of enforceable solvency

The analysis of all the risks escapes to the object of this work that affect the insurance activity, as well as their quantification. We will limit only to do one first arrangement of modalities of life insurance which we have studied in the previous sections, that we believe contemplate all the possibilities of supply of the insurance firms that operate in the life sector, from the viewpoint of the procedure of allocation of the yields to the insured.

As regards the risks, that we will analyze, we anticipate that they will be only two. The technical risk and the risk of investment, in the definitions about the same that we have established in the previous point, discarding the analysis of the environmental and operational risks of, not because they are less important, but because the amplitude of its study goes beyond the object of this study.

On the other hand, we have limited ourselves to carry out an arrangement of the different modalities of allocation of profits to the insured based on the greater or smaller risk that implies for the firm, indicating the critical points of each one of them. All the factors of risk that we will indicate are additional to the volume risk, the only one that it is now taken into consideration for the calculation of the margin of solvency.

The conclusions are set out in the table that appears next. With it and with a brief note on the critical aspects of each modality, we will bring our present contribution to the subject to an end.

Characteristics	**Factors That Affects Techical Risk** +	 --
TYPE OF RISK	Survival	Life
TECHICAL INTEREST:		
GUARANTEE	Guaranteed	Policyholders' risk
QUANTITY	Elevated	Conservative or non existent
TERM OF GUARANTEE	Long	Short
STABILILAZATION	Constant	Decreasing
COMUNICATION	Ex ante	Ex post
PROFIT-SHARING	Without interannual compensation	With interannual compensation
MORTALITY:		
TYPE OF TABLE	General Population	Insured population
TERM OF GUARANTEE	Long	Short
IN LIFE	Without Projecting	Projected
IN DEATH	Projected	Slanted
IN MIXED	Common for both risks	Different for each risk
INDEPENDENCE	Independent Mortality	Depend between heads
SEGMENTATION:	By age and sex	Other factors of risk
TYPE OF PROVISION:	Profit	Capital
TERM:	Long term	Short term, renewable
PREMIUM:		
SYSTEM OF PAYMENT	Periodical	Single
FOR RISK OF DEATH	Adjusted	Of risk

RIGHT OF SURRENDER:	Restricted (actuarial capitalization)	Generalized (financial capitalization)
MATHEMATICAL RESERVES:	Retrospective	Prospective
REINSURANCE: CUMULOS HOMOGENENIZATION	Without protection Portfolio without standardise	With protection Standardization

Characteristics	**Factors That Affects the Investment Risk**	
	+	**--**
TYPE OF INVESTMENT:	Variable Profit	Fix yield
TYPE OF INTEREST PROTECTION:	Individual immunization	ALM
FREQUENCY:	Current Coupon	Coupon Cero
SURRENDERS PREDICTION:	Without forecast surrenders	With forecast surrenders
DIVERSIFICATION:	Concentration	Diversification
ISSUER:	Quoted	Classified

The modalities that we have examined in the first sections are exposed to the risks mentioned with different intensity. In this way, the critical factors, in the classic insurance, will be the quantity the guaranteed interest type and the term of guarantee. As well as the table of mortality and the term of guarantee of the same, the benefits in the form of rent, the calculation of the mathematical provision, the class of investment, the risk of the issuer and the replication of the portfolio of investments to the maturity dates of the insurances (ALM), considering the recoveries forecast.

In the insurances with predetermined investments the main risk is in the mortality and the risk of the issuer, as well as in the surrenders forecast, like in the profit-sharing policies, including in these the non forecast of inter annual compensation of profits.

In the policies related to movable investment funds or internal funds, the risk is in the mortality and the surrenders forecast, although if they are partially linked or they offer provision benefits, they would also be subject to analogous risks than the traditional insurance.

The *Universal Life* policies present/display the firm with a much attenuated level of risk, mainly when the term of every period is very short; nevertheless they are subject to risk of recoveries, just as it happens in the policies with defined benefits.

The election of the methods for the quantification of each risk, as well as the extension of the study to the other operations and risks that affect the activity will be without a doubt object of analysis in the coming years by the investigators, since it constitutes a new branch of study in permanent evolution.

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NOTES

[1] Recently some insurance firms have decided to guarantee a rate of profitability for a determined number of years, and later lower rates for longer terms.

[2] On this effect, professors of the department Economic of the U.B, Financial and Actuarial Mathematics are working conducted by professor Antonio Alegre Escolano.

[3] See the work of the author *"El Seguro de Vida y la Depreciación Monetaria"*, Deusto (1983), in which the solutions are exposed in view of the inflationary problem.

[4] In Navarro and Nave (2001): *"Fundamentos de matemáticas financieras"*, Ed. A. Bosch, a complete review of the immunization procedures.

[5] Bierwag and Kaufman (1985): "*Duration gaps for financial institutions"*, Financial Analyst's Journal, July-August; Bierwag (1987): *"Duration Analysis. Managing interest rate risk"*, Ballinger Publishing Co., Cambridge, Massachusetts; Manzano (1992): *"La gestión del riesgo de interés: el análisis de la duración"*, Banco de España, Boletín Económico, July-August

[6] Dynamic models described by Lee and Chao (1992): "A rebalancing discipline for an immunization strategy", Journal of Portfolio Management, summer; and Navarro and Nave (1997): "Dynamic immunization and transaction costs with different terms structure models", Journal of Actuarial Practice, vol. 5 nº 2.

[7] In the doctoral thesis of the author (1977): "Efectos de la depreciación monetaria en el seguro de vida", the structure of the investments of the insurance firms in Spain is analyzed. The assumption of investment in an identical portfolio to the one of the whole sector, by means of the disinvestment procedure each 31 of December and investment each first of January. With the purpose of gathering, the effect of the latent capital gains and it is compared with the obtained real profitability in investments in actions, obligations, real estate and other assets by the totality of operators. The conclusions that are obtained i) the global profitability of the whole investments is superior, for any period, to the one of the fixed profit and ii) the profitability obtained by the insurance firms is smaller because of the legal restrictions that regulate the investments.

[8] See the book of the author (1977): *"Aportaciones técnicas a la gestión del seguro de vida"*, Ed. Colegio Nacional de Agentes de Seguros.

[9]The different forms of attribution from the excesses of the insured can be studied in the book of the author (2001*"Conociendo el seguro. Teoría general del Seguro"* (pages 302 to 313), Ed. UMESER.

[10] This modality of insurance was analyzed by the author in the book (1977): *"Aportaciones técnicas a la gestión del seguro de vida"*, Colegio Nacional de Agentes de Seguros, in that it was observed that its implantation in Spain was made difficult by the legislation on investments of the insurance firms, when demanding that these were made directly in certain proportion in values of the State. Later, in the book, also of the author (1983) *"El Seguro de Vida y la Depreciación Monetaria"*, Deusto (1983), He formulated (pages 61 to 102) a general an actuarial theory of the life insurance linked to investment funds, and established three possible typologies for such. Category A, according to the terminology of Grant and Kingsnorth (1967), consisting of a direct investment in participation of a fund, with the complement of death insurance. Category B, consisting of the acquisition, every year, by the insurer, of the n ésima part of the capital insured in participation of a fund, so that in this case if a rate of discount in the premium is applied. And category C, in which they are acquired at the initial moment participation of the fund by a value equivalent to the insured capital, so that the organization covers with own resources, as a loan to the insured, the difference between this capital and the value of the premium. Finally, in the book (2001) *"Conociendo el seguro. Teoría general del seguro"* (pages 302 to 313), Ed. UMESER. The author refers the modality of life insurance linked to investment funds that practice habitually in Spain. It consists of one fourth modality in which the organization acquires every year the number of participation of the fund which are possible to be acquired with the premium of the insurance, deduces the premium of the death insurance and the expenses, and refers the provisions of the insurance to the sale value of the participation.

[11] Benjamin (1966): "*Putting Computers on the actuarial work"*,, Journal of the Institute of Actuaries, vol. 92, by means of the Theory of Games establishes the surcharge to apply in case of guaranteeing minimum deviations and it contrasts it with the experience of 20 years; Squires (1974): *"Unit linked assurance: observations and propositions"*, Journal of Institute of Actuaries, vol. 101, part I, carries out a study of smaller consistency because of the weakness of the departure hypotheses, also on stock-market of the United Kingdom. The author, in his work (1983) *"El Seguro de Vida y la Depreciación Monetaria"*, Deusto (1983), analyzes returns average of the main values that quote in the Spanish stock-market and its high standard deviations concluding in the impossibility to offer this guarantee in Spain at the time at which he made the study (pages 97 to 101).

[12] The author referred to this modality for the first time in the academic year (1984) *"Seguros de Vida"* for formation of executives of insurance for the Latin American Federation of Insurance Firms (FIDES). He also included it in his book (1986) *"Seguros de Personas"*, Ed. Consejo General de Agentes y Corredores de Seguros de España (pages 170 to 177). This modality of insurance was the one of greater impact in the United States in the decade of the 80s.

[13] These modalities are described in the book of the author (2001) *"Conociendo el Seguro. Teoría general del seguro"* (pages 302 to 313), Ed. UMESER.

[14] At present, the margin of solvency only depends, in the branch of life, of the volume of the mathematical provisions that the insurance firm manages: a 4% of the mathematical provisions in all the modalities of insurance, percentage that is reduced until 1% in the insurances with risk of investment in charge of the taker, plus 0.3% of the capitals in risk of death insurances, numbers that are reduced proportionally with those of reinsurance, in agreement with the present Law of Insurance.