Internal models in

In this article, we analyse the advantages of the usage and implementation requirements of internal models in the Solvency II framework. By way of example, we developed an internal model for the quantification of business through approximations for the coefficient of the loss of portfolio, using real data of policy cancellations for an insurance company's general branch of business. The methodology used was original as it incorporated the contagious effect that exists amongst decisions to cancel policies. The results are compared with those that would be obtained by applying the standard model and with those obtained assuming independence in the decision to cancel. We concluded that to ignore the effect of contagion would lead the insurer to underestimate its exposure to this risk, making the proposed internal model more suitable for quantifying the company's specific business risk.

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Their application in the calculation of the coefficient of loss of portfolio

Solvency II:

ILLUSTRATION STOCK

The European Solvency II Directive (Directive 2009/138/CE of the European Parliament and of the Council) intends that insurers maintain a sufficient total level of technical reserves and solvency capital to guarantee stability against adverse external fluctuations. In summary, the intention is that insurers should maintain a financial level in relation to the commitments acquired and that they guarantee the protection of the insured (Ferri *et al.*, 2010).

It is well known that Solvency II is based on three pillars. The first refers to quantitative requirements where there are two fundamental magnitudes: the solvency capital requirement (SCR) and the minimum capital requirement (MCR). The second pillar centres on qualitative requirements, specifically the management of risks and the applicable supervision regulations. Lastly, the third pillar refers to the communication of information to the supervisors and interested parties.

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The fourth section of the Directive on SCR establishes that this must correspond to the value at risk (VaR) of own funds calculated with a 99.5% confidence level. To calculate it, all quantifiable risks to which an insurance undertaking is exposed have to be taken into account, including potential losses and the adverse revaluation of assets and liabilities over the period of a year.

Solvency II also offers various methods of calculating the SCR which are basically related to the so-called standard and internal models. This article concentrates on the second of these methods and, by means of empirical applications, illustrates the use of internal models for quantifying business risk and develops scenarios on the coefficient of loss of portfolio.

The work is structured as follows. In the second section we look at certain fundamental characteristics of the standard model and internal models that come out of the Directive. The potential advantages that can be derived from the internal models are contained in the third section and, in the fourth section, we consider the regulation requirements with which the models have to comply. The fifth section, with an empirical content, presents the results obtained from the application of an internal model, developed by the authors, for the quantification of business risk through approximations of an insurer´s loss in portfolio. Lastly, in section six, we present the principal conclusions obtained from the study, together with the final recommendations.

Standard model vs. internal models

The standard model establishes a general formula for determining the SCR. Article 103 of the Directive indicates that the SCR is the sum of three items: the basic solvency capital, the capital requirement for operational risk and an adjustment for the loss-absorbing capacity of technical provisions and deferred taxes. This model contemplates the aggregation of risks so that the basic solvency capital is the sum of the underwriting risk (life, non-life and health business), the market and credit risks.

On the other hand, internal models are not based on a generic formula but are constructed on hypothesis based on the insurers experience and have to be properly justified. Specifically, Solvency II requires undertakings to demonstrate, with documentation, the structure and working of these models, referring to the statistical quality of the data employed, the calibration standards, assigning of profit and loss and

validation rules of the model (articles 118 to 122 of the Directive). Those companies that decide to use an internal model must obtain authorisation from the supervisory authorities and demonstrate that it is widely used.

The internal models can be partial or full. The former are applied in the basic SCR modelling, i.e. in determining the capital requirement for operational risk or to quantify the adjustment for the loss-absorbing capacity of technical provisions and deferred taxes.

They can also be applied to the whole of the business or only to some of the main business units. In general, the structure of risks on which they are based can be different to the standard model but, if it is a full internal model, it must at least evaluate those risks considered under the standard model.

Potential advantages of using internal models

On the one hand, we should point out that the standard model can be less complex and time-consuming in its implementation than an internal model. In our opinion, we consider it to be adequate for companies that have a limited data base and have little experience in modelling their risks. Moreover, on a European level, it provides a harmonized approach to the measurement and categorizing of risks. However, as it is directed at a very heterogeneous group of insurers in respect of size, types of business, etc., it can sometimes contain very general and excessively conservative specifications. In general, we would say that it is applicable to the risk profile of the majority of insurance companies but, in certain cases, it is possible that this normalised approach does not reflect adequately a company´s specific risk profile.

On the other hand, internal models are developed within the company itself and analyse the global position of its specific risk based on its own information. The quantifying of the risk is undertaken using duly validated statistical methods and providing the technical-actuarial rigour on which these models are based. So, whilst the standard model is generic and applicable for any insurer, the internal model is specific to each company and, therefore, can be more precise for analysing a risk´s specific profile.

In this sense, we would emphasize the great potential available today, within the Solvency II framework, through modelling statistical techniques for quantifying risks and their correlations. Amongst other aspects, they facilitate the study of the

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behaviour of risk measurement in different scenarios. Moreover, as far as the classification of risks is concerned, the internal models can follow the same, or similar, proposal as the standard model, always with the objective of reflecting, as well as possible, the global position of the company´s specific risk. For that reason, we would say that the internal models can contribute to the company being able to carry its business in a more efficient manner by identifying those business areas that are more profitable and facilitating an effective application of risk mitigation techniques.

Internal models: requirements for their implementation

Articles 118 to 125 of the Directive refer to the requirements that have to be complied with by the internal models. Specifically, the undertaking has not only to demonstrate that the internal model is widely used but, also, that it has an important role in the governance system, in particular, in the risk management system, decision taking, evaluation processes and assigning financial capital. Moreover, the frequency of the SCR calculation, via the internal model, has to be coherent with its use. Regarding the responsibility of guaranteeing the suitability of the internal model, the Directive states that this lays with the management or administrative body (article 118).

The statistical quality requirement is laid down in article 119. To be precise, it states that the methods used for determining the probability distribution must be based on actuarial techniques, adequate statistics and should be coherent with the methods used by the company to calculate the technical provisions. Moreover, up-to-date and reliable information should be used and based on realistic suppositions. With regard to the data used, the Directive states that it must be exact, complete and adequate.

Whilst it does not prescribe a specific method for determining the distribution of probabilities, the internal model should classify the risk adequately in order to guarantee its general application and carry out a fundamental role in the undertaking´s system of governance, their risk-management system and decision-making processes, and capital allocation. Additionally, the internal model shall cover all of the material risks to which insurance and reinsurance undertakings are exposed and, as a minimum, in the case of full internal models, those considered under the standard model.

The internal models also contemplate the possibility of considering the existing dependencies between the different risk categories and amongst themselves which, in any event, have to be justified. The effect of risk mitigation techniques can also be taken into account provided that the model adequately reflects the credit and other derived risks. On the other hand, those risks associated with financial guarantees and contractual options have to be evaluated precisely, provided that they are significant.

Moreover, in the internal model, you can contemplate the measurement of future actions that are expected in the event of certain circumstances and can indicate the necessary execution time. In the same way, the model will take into account all forecasted payments to policyholders and beneficiaries, regardless of whether they are

contractually guaranteed. Also, one can use time horizons or risk measurements different to those established for the basic SCR provided that the necessary protection level is guaranteed for policyholders and beneficiaries. In this case, the SCR will be calculated from the distribution of probabilities generated from the internal model using the VaR of own funds at 99.5%. If the company cannot obtain the SCR directly from the distribution of probabilities generated by the internal model, approximate calculations can be used, provided approval is obtained from the supervisory body.

Similarly, the undertaking must demonstrate that the categorizing of risks used in the internal model explains the causes and sources of profits and losses and must review it, at least annually, for each main business unit.

Lastly, the company must check the working of the internal model by means of a periodical validation cycle, verifying that its specifications are still adequate and comparing the results obtained with the reality. This process is based on a statistical process that includes the verification of the validity of the distribution probabilities, as well as an analysis of the stability of the model and the sensitivity of the results compared to variations in the initial hypothesis.

An example of the internal model for the risk management of the business

Without a doubt, the positioning of the insurance company in the market constitutes an element of risk which is reflected in the loss of portfolio registered every financial year. Recent studies (Guillén *et al.*, 2006, Guillén *et al.*, 2008, y Pieschacón, 2010) have shown its importance for the industry and, therefore, in the Solvency II framework, it is fundamental to quantify this risk. In this section we will show an example of the internal model applied to the risk management of business in the insurance environment. For this purpose, we will use data on policy cancellations provided by an insurance company and from which we developed loss of portfolio scenarios in the general insurance class.

The methodology used is that proposed by Ayuso *et al.* (2011a) in which an alternative is offered to the standard model for determining the loss coefficients. This contribution consists of considering the contagious effect that exists between the

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cancellations of policies. We also compared these results with those obtained using the standard model and, in addition, with those obtained assuming the decisions to cancel were taken independently.

In this particular case, the period studied covered from 31st. December, 2005 to 31st. December 2007, and we considered all of the policies within three types of non-life branches: motor, accident (which includes household, funeral expenses and personal accident) and health insurance. The sample consisted of 300,386 policies in force at the beginning of the study. We segmented them according to type (motor, accident or health) and their length of time in force at the beginning of each of the six month periods analysed (differentiating between whether the policy was in its first, second, third year or more). We used these segmentation variables since previous studies (Brockett *et al.*, 2008) show that the probability of cancellation depends, amongst other factors, on the type of policy and its age.

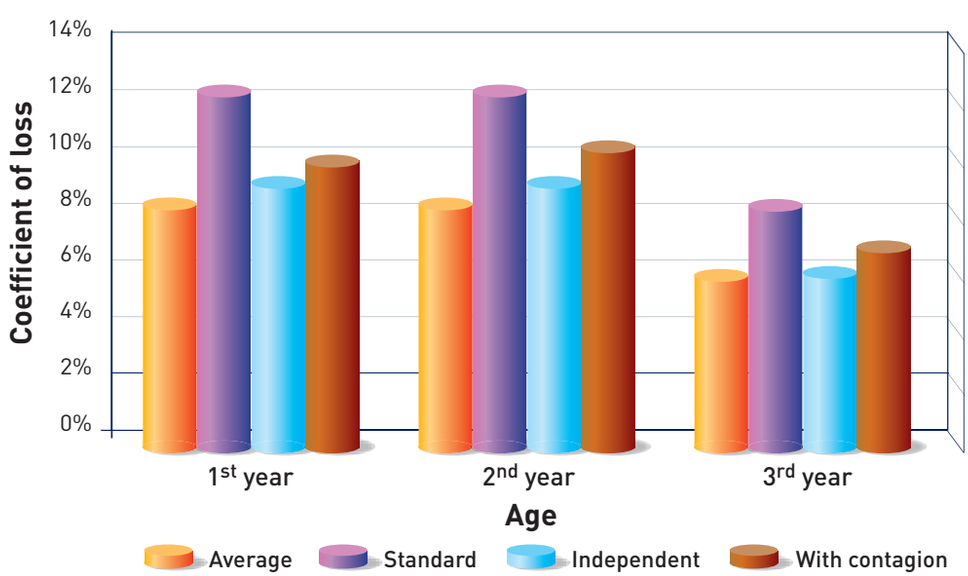
In this way, we determined four coefficients for each segment analysed: the average[1] coefficient of loss, the coefficient of loss under the standard model (which consists basically in increasing the average coefficient by 50%), the one for the case where we assumed independence (absence of contagion) and one that incorporated the contagious effect between cancellations[2]. As we indicated before, the specific formulae used in the calculation can be found in Ayuso *et al.* (2011a).

In figures 1, 2 and 3 we show these four coefficients of loss for the accident, motor and health branches respectively. Whereas figure 4 shows the overall results for the three branches of business analysed. The details of the values used in the construction of the four illustrations can be found in Ayuso *et al.* (2011b).

[1] In this study we assigned the same weighting to the different periods analysed, so the coefficient of loss is nothing other than the arithmetical mean of the six monthly registered percentage of portfolio loss. The percentage of loss is also shown as the quotient between the number of cancellations observed during the period and the number in force at the beginning of said period.

[2] In the last two cases, the confidence intervals have been constructed at a level of 99.5%.

Figure 1. Coefficients of loss for the Accident branch.



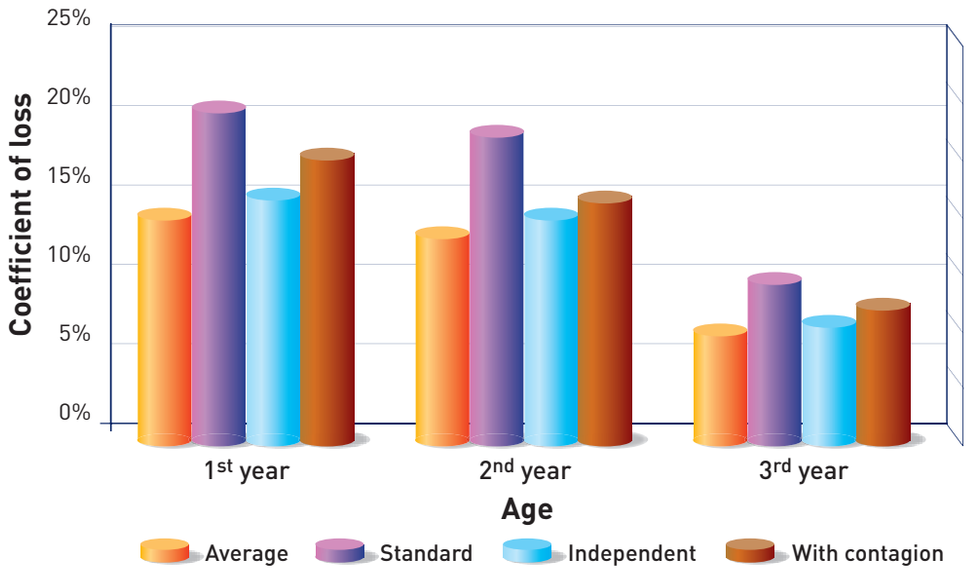


Figure 2. Coefficients of loss for Motor insurance.

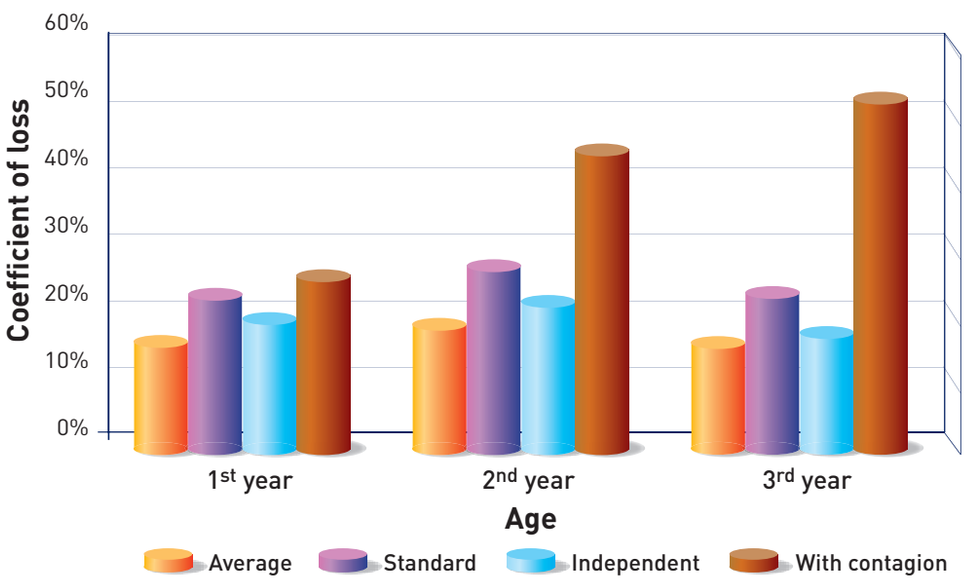


Figure 3. Coefficients of loss for the Health branch.

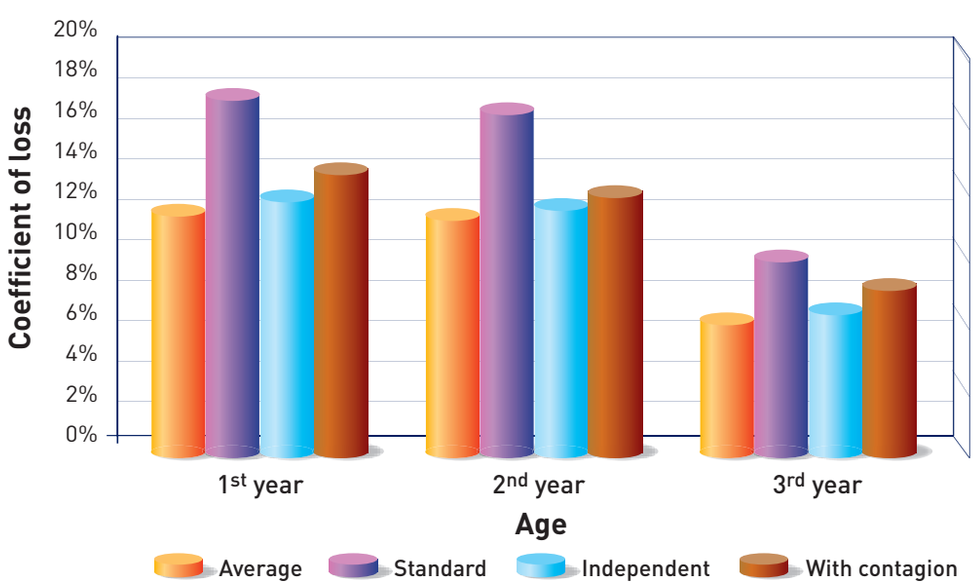


Figure 4. Coefficient of loss for the three general insurance branches.

The coefficients of contagion obtained following the methodology described in Ayuso *et al*. (2011a) are presented in table 1.

Table 1. Coefficients of contagion*

Product	1st. Year	2nd.Year	3rd + Years
Accident	0.11	0.19	0.12
Motor	0.54	0.09	0.17
Health	4.50	32.33	71.50
General	0.19	0.03	0.21

**The coefficient of contagion r is shown multiplied by 1000, r*1000.*

In general, we can indicate that the health policies are those that register the greatest coefficients of loss, followed by the motor and accident branches. We can also say that, as one would expect, the coefficients of loss reduce as the years in force of the policies increase (except in the case of the health branch).

At the same time, we can observe that the standard model shows higher models than those obtained under the hypothesis of independence. They are also higher than those corresponding to the assumption that there is contagion amongst the cancellations, except in the case of health insurance. This is due to the fact that they do not reflect the fact that the decisions to cancel in the health branch are very co-related and this produces high levels of contagion which are apparent in table 1 for this specific branch.

We concluded, therefore, that the standard model is too conservative and produces excessively high coefficients which could be due to its construction, consisting in increasing the loss coefficient obtained by

50%. However, neither the standard model, nor that based on the independent hypothesis, pick up the high level of correlation that exists between the decisions to cancel in the health branch, for which we should obtain a much higher coefficient to those registered for these two models. On the other hand, the model that assumes independence between the cancellation decisions underestimates the risk since it shows lower coefficients than those registered in the case where contagion is presumed.

Lastly, figure 5 shows the results obtained for coefficient of loss assuming that contagion exists in the cancellation decisions, according to the level of confidence. Taking a 99.5% confidence level as a reference and considering the policies in their first year in force, the coefficient value is 13.46% and reduces to 12.61% for a confidence level of 97.5% and 14.88% for a 99.9% confidence level. In conclusion, the data represented in figure 5 describes the sensitivity of the coefficient of loss when there are changes in the level of confidence and, therefore, can provide the company with valuable information for properly managing its business risk as it shows a greater propensity to cancel during the first year of the policy.

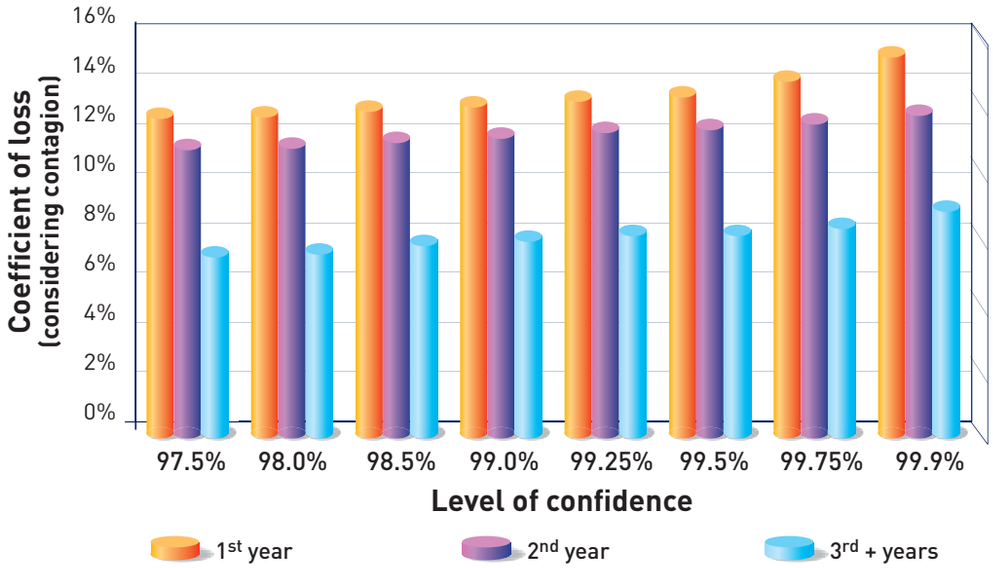


Figure 5. Coefficients of loss (assuming contagion) according to the confidence level. Results for the three general insurance branches.

By way of summary, we can say that the internal model presented enables the presentation of loss of portfolio scenarios considering that the cancellation decisions are produced as a «chain reaction». In our example, prepared with real data, we have established the existence of this contagion and that it has an important impact on the results. In fact, the greater the degree of contagion, the greater the error that we will make in the preparation of scenarios for the loss coefficient assuming independence in the decisions. On the other hand, the standard model is too conservative in the majority of the cases, giving rise to excessively high percentages of loss. As a result, to not take into account the dependency that exists between the cancellation decisions of the insureds will lead the company to quantify incorrectly the real business risk exposure whilst, to use the standard approximation, can imply excessively unfavourable scenarios.

Conclusions and final recommendations

In this article we have summarized some of the potential advantages of using internal models in the context of Solvency II and the regulatory requirements that have to be followed for their implementation. By way of example, we carried out the application, with real data, of the methodology proposed by Ayuso *et al.* (2011a) for the development of an internal model applied to the management of business risk through approximations of a company´s loss of portfolio. This methodology considers the impact on the results of the existence of a certain contagion between the cancellation decisions of the insureds and, thus, the

scenarios formulated are more realistic and precise than those obtained using the standard model.

The internal model that we have presented, by way of example, allows us to conclude that to ignore the effect of contagion and assume independence in the decisions to cancel policies introduces an error in the estimations that could lead an insurer to underestimate its business risk. Also, the standard model tends to produce excessively conservative coefficients. Our recommendation would be to carry out the analysis developed in this study for different types and durations of policies in view of the fact that both can affect the probability of cancellation.

In any event, we consider that this article illustrates the great potential of internal models in the management of risks and also contributes some general guidelines for insurers in respect of the correct preparation of loss of portfolio scenarios and, as a result, the measurement of exposure to the business risk, within the framework of Solvency II.

Bibliographical references

AYUSO, M., GUILLÉN, M. & PÉREZ-MARÍN, A. M. *Methodology for the calculation of scenarios with loss of portfolio in Solvency II with contagion between cancellations. Annals of the Spanish Institute of Actuaries,* 2011a, nº 17, 13-30.

AYUSO, M., GUILLÉN, M. & PÉREZ-MARÍN, A. M. *Methodology for the calculation of loss of portfolio considering contagion between cancellations in general insurances.* Research on Insurance and Risk Management: Riesgo 2011, Eds.: J. M. Feria, E. J. Jiménez y M. Guillén. Madrid: MAPFRE Foundation Notebooks, 2011b, nº 171, 109-121.

BROCKETT, P. L., GOLDEN, L., GUILLÉN, M., NIELSEN, J. P., PARNER, J. & PÉREZ-MARÍN, A. M. *Survival analysis of household insurance policies: how much time do you have to stop total customer defection?.* Journal of Risk and Insurance, 2008, vol. 75, nº 3, 713-737.

Directive 2009/138/EC of the European Parliament and of the Council of 25th.November, on life insurance, the taking up and pursuit of insurance and reinsurance (Solvencia II).

FERRI, A., RODRÍGUEZ, P. & ROMERO, M. J. *Risk Management. A study on the insurance sector in Spain in 2010: qualitative aspects of Solvency II.* Dir. P. Blanco-Morales y M. Guillén, Fundación de Estudios Financieros, 2010, nº 38, 111-129.

GUILLÉN, M., NIELSEN, J. P. & PÉREZ-MARÍN, A. M. *The duration of different insurance policies in the household – an integrated approach.* Gerencia de Riesgos y Seguros, 2006, nº 96, 23-32.

GUILLÉN, M., NIELSEN, J. P. & PÉREZ-MARÍN, A. M. *The need of monitoring customer loyalty and business risk in the European insurance industry.* Geneva Papers on Risk and Insurance – Issues and Practice, 2008, nº 33, 207-218.

PIESCHACÓN *JR.*, C.A. *The loss of life portfolio and its consequences,* Actualidad Aseguradora, 2010, 10-11.