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Liquidity risk and Solvency II

Abstract

This paper discusses the importance of liquidity risk when evaluating the risk of portfolios of financial assets that insurance companies hold. Until very recently and within the scope of Solvency II, liquidity risk was only considered under Pillar II, i.e., the proposal was that insurance companies should perform a mere qualitative evaluation of it. Nowadays the possible quantitative evaluation of liquidity risk is under debate but it is still unclear if it will apply only to liabilities or to portfolio holdings as well.

The authors argue that liquidity is an important source of market risk and that it should be measured quantitatively when accessing the overall market risk of portfolio holdings. Based upon the financial liquidity literature, they propose a way to measure liquidity risk quantitatively. The proposed method is simple, relies on publicly available data, and is consistent with the VaR approach underlying Solvency II.

This paper implements the proposed method on the Portuguese insurance sector, using actual portfolio holdings. The main empirical findings confirm that liquidity risk is an important risk representing, on average, more than 10% of the overall market risk insurance companies are exposed to.

Keywords: liquidity risk, value-at-risk, Solvency II, insurance regulation.

Introduction

The recent financial crisis and subsequent turmoil in financial markets have sparked new questions about the perception and evaluation of liquidity risk. This discussion has taken place in the context of a new regime that aims to supervise and regulate insurance and reinsurance in the European Union, the Solvency II Directive, which will come into force by the end of 2012.

The period preceding the economic and financial crisis witnessed extraordinary economic performance worldwide, with never before seen growth rates and strong gains in the stock markets. Record low interest rates led to a boom in the residential housing markets, and this coincided with the development and proliferation of new, innovative structured credit products. When several credit institutions in the US holding subprime mortgages went bankrupt, it was rumoured that there could be significant losses in hedge funds which had invested in products that were based on subprime mortgages. As a result, investors became concerned about the evaluation of all financial credit instruments, and ratings agencies began to downgrade the ratings of some companies and structured financial products. The problems in the credit markets spread to other markets, leading to generalized lack of confidence and consequent lack of liquidity in financial markets, the banks raise their spread rates significantly, and this in turn led to the collapse of some major investment banks. This credit and liquidity crisis in the banking sector quickly spread to the insurance sector, to the extent that the largest insurance company in the world at the time faced severe liquidity problems. The situation was brought about by its investment in credit default swaps and the huge number of policy holders wishing to surrender policies that involved financial insurance due to their loss of confidence in the financial capacity of the company.

In such a context, with the world struggling to get out of the recent credit and liquidity crisis it is puzzling the debate on how to evaluate risks insurance companies are exposed to, seemed to overlook the importance of a proper evaluation of liquidity risk. In fact, it was not until very recently, in its March 2010 report, that the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) first recognized the importance, at least for liabilities, of a quantitative evaluation of liquidity risk (under Pilar I). Before that report, liquidity risk was considered only under Pilar II and the recommendation was a mere qualitative evaluation. In which way – qualitative or quantitative – liquidity risk embedded in portfolio holdings should be taken into account is currently under debate. It is our opinion that liquidity is an important source of market risk that should be measured quantitatively, when accessing the overall market risk of portfolio holdings.

In this study we, therefore, focus in measuring liquidity risk of portfolio holdings and propose a concrete way to take liquidity risk into account when accessing the market risk insurance companies are exposed to, in the context of Pilar I of Solvency II.

1. Liquidity risk in the insurance sector

Liquidity risk is one of the most important risks to affect the solvency of insurance companies. Simply put, it reflects the available resources and capacity of the insurer to manage the financial flows to ensure that the company is able to meets its responsibilities when they fall due.

Most of the recent cases of insolvency occurred in the life insurance branch, as policy holders lost confidence in the company and surrendered policies that had a guaranteed interest rate. The sheer volume of policies surrendered left insurance companies with no means of making the payments due. In general, this was because the assets backing the policies were non-liquid in the short term, giving rise to high losses when they were converted. In the remaining cases, resorting to short term loans – often because non-liquid assets could not be converted without incurring considerable losses – meant paying high interest rates, and when it was no longer possible to pay creditors, the insurance company went bankrupt. There are other, albeit less common, cases that can affect the liquidity of an insurer and place the company at risk of insolvency. These include having to pay out for large indemnity claims, operational problems in collecting policy holder premiums, and bankruptcy of the banks where securities are deposited and margin calls on derivatives.

Regardless of the reasons for which an insurance company may be called upon to pay out, the simple fact that much of its equity is invested in securities, which cannot be readily or without costs converted into cash, constitutes a risk. Further, because this kind of liquidity risk is directly associated with the holding of investment portfolios by insurance companies, it should be seen as an integral part of the market risk of portfolio holdings.

Shamroukh (2000) looks at liquidity risk as a component of market risk. He defines it as the risk of loss associated with the costs of liquidation of a position for a particular asset, especially those stemming from the difference between the sell price and the buy price (exogenous liquidity risk) and those brought about by the impact of the number of transactions on prices (endogenous liquidity risk). According to Bervas (2006), market liquidity can be described in terms of the magnitude of the bid/ask spread, market depth, i.e., the volume of assets that can be traded without distorting the current market prices, and market resilience, i.e., the time taken for the price of a certain asset to return to its initial pre-traded value. While the first feature is understood as a direct measure for evaluating transaction costs, the latter two are indicators for the market's ability to absorb significant volumes of trade without substantially affecting asset prices. Bangia et al. (1999) consider that the price of an asset includes not only the risk stemming from fluctuations in price, interest rates and exchange rates, but also liquidity risk – exogenous and endogenous.

1.1. Measuring liquidity risk. Studies that aim to measure financial market liquidity risk can be broadly classified into two groups: those that measure exogenous risk, by means of what are often called spread measures, and those that measure endogenous risk by means of impact measures. Spread measures are easier to calculate and they are sufficient for the small investor. However, for institutional investors, who carry out high volumes of trading, spread measures underestimate liquidity risk because they do not take into account the impact of trading volume on prices. Using impact measures, on the other hand, suffers from the disadvantage that most of the impact measures can only be calculated a *posteriori* or they depend on information that is hard to obtain.

The most common spread measures are: (1) conventional bid/ask spread, which measures the difference between the sell price (ask) and the buy price (bid); (2) percentage quoted spread (*Qspread*), which is the ratio of the difference between the sell price and the buy price to the bid/ask price midpoint of the asset; (3) effective percentage half-spread or *Espread* (Korajczyk and Sadka, 2008), which measures the ratio of the absolute difference between the transaction price and the bid/ask price midpoint of the asset to the bid/ask price midpoint; (4) $\textit{Effective spread}_{TAQ}$, which is calculated by the New York Stock Exchange Trades and Automated Quotes Database (TAQ) and measures the bid/ask spread as twice the absolute difference between the transaction price and the midpoint of the bid/ask spread; (5) c-Roll indicator (Roll, 1984), which measures the effective bid/ask spread in terms of covariance of changes in price; (6) effective tick (Holden, 2009; Goyenko et al., 2009), which represents the ratio of a probability-weighted average of effective spreads to the average price in a time interval; (7) H-spread (Holden, 2009), which consists of a weighted average of the possible spreads; (8) *LOT* (Lesmond et al., 1999), which measures the difference between the percentage of transaction costs from a sell and the percentage of transaction costs associated with a buy; and (9) zero indicators (Lesmond et al., 1999), which measure the proportion of days with *zero* returns and/or nil volume in a month.

The most popular impact measures are: (1) quote size, which measures the quantity supplied and the quantity ordered using realized sell and buy prices; (2) trade size, which measures the quantities traded; (3) trading volume, which measures the volume traded; (4) trading frequency, which measures the number of transactions within a certain price range; (5) illiquidity and extended illiquidity (Amihud et al., 2002; Goyenko et al., 2009), which measure the relationship between the volume and returns of an asset and the relationship between the bid/ask spread and the volume; and (6) Kyle's (λ) (Kyle, 1985), which measures asset price sensitivity to quantities traded.

Because we seek a way to measure liquidity risk that is compatible with market risk as set out in Pillar I of Solvency II, it is important to understand how to adapt the above measures in terms of value-at-risk (*VaR*). In financial mathematics and financial risk management, *VaR* is a widely used risk measure of the risk of loss on a specific portfolio of financial assets. For a given portfolio, probability level and time horizon, *VaR* is defined as a threshold value such that the probability that the mark-to-market loss on the portfolio over the given time horizon exceeds this value (assuming normal markets and no trading in the portfolio) is the given probability level. Although one can find some *VaR*-like concepts in history, *VaR* did not emerge as a distinct concept until the late 1980s. The triggering event was the stock market crash in 1987. Since then academics have witnessed constant debated about the appropriateness of such a simple measure when evaluating risk. Nowadays the consensus seems to be that evaluating *VaR* is clearly not enough (see, for instance, Artzner et al. (1999), Acerbi and Tasche (2002), Fritelli and Gianin (2002), or Dow and Blake (2006)). Despite its problems, *VaR* has become a reference measure in the evaluation of market risk and investment risk management. In the framework of Solvency II, *VaR* estimates are used for all market risk evaluation. Of course one could criticize the adoption of such a simple measure when a wider and less problematic class of risk measures is available in the management literature. In this paper, however, we go along with the accepted practice, adopt *VaR* as the risk measure, and focus only on liquidity issues.

VaR is traditionally calculated on the assumption that liquidation of an asset has no impact on market prices. Such an assumption is reductionist for illiquid assets, so some authors have proposed a means by which liquidity risk can be incorporated in the calculation of *VaR*. Lawrence and Robinson (1995) first proposed a simple rule that adds the time estimated to liquidate the investor's position to the time frame calculation. However, this approach does not take into account volatility in the asset's bid/ask spread; it assumes that the investor's entire position is liquidated in a single transaction, and for a portfolio of assets, the same time increment is held for all assets, disregarding the individual features of each asset. A second simple rule that is often used adds half of the average bid/ask spread to conventional *VaR*. This approach similarly ignores bid/ask spread volatility over time. In order to overcome these limitations Bangia et al. (1999) developed a model to quantify *VaR* using exogenous liquidity risk. They argue that using the average price does not adequately reflect the level of risk; it is also necessary to include the magnitude of the difference between the average price and the possible sell price by means of the bid/ask spread and the respective volatility. This approach takes into account both uncertainty in the profitability of the assets as well as uncertainty deriving from liquidity risk. Le Saout (2002) extends Bangia et al.'s (1999) model to more adequately capture both the exogenous and the endogenous component of liquidity risk. He replaces the bid/ask spread with a weighted average bid/ask spread. This is weighted by the depth of the respective buy and sell prices. Although this model is theoretically more complete, it is difficult to apply due to the difficulty of obtaining information on the depth of buy and sell prices. This difficulty has prompted some studies on endogenous liquidity risk to focus on liquidation strategies as a mitigating factor of the risk rather than using them to quantify it. A good example of this kind of study is that by Shamroukh (2000), who considers a trade-off between the average of and the variance in the assets' sell prices. In fact the quicklier the investor's position is liquidated, the greater the liquidation costs, but the lesser the volatility in prices. Hence, the optimal strategy is that which minimizes the theoretical *VaR*, and this depends on the sensitivity of the volatility and the assets' endogenous liquidity to the time needed to liquidate the position. The author concludes that assets whose liquidity costs are low should be liquidated earlier since the effect of the average on *VaR* is greater than that of the variance in speedy liquidations.

1.2. A concrete proposal in the context of Solvency II. For the purpose of quantifying *VaR* market risk with Solvency II, we find Bangia et al.'s (1999) model the most appropriate in light of its simplicity and the information it requires. Its main drawback is that it does not include endogenous liquidity risk; hence, it underestimates the true liquidity risk. However, this miscalculation is not as drastic as that obtained by the current model used to quantify market risk, in which liquidity risk is simply ignored.

Bangia et al.'s (1999) model is also appealing because of the way it breaks down into three steps. First, *VaR* is determined conventionally without liquidity risk. Then, liquidity risk (VaR_L) is determined, and last, *Va*R is corrected for liquidity risk. The final adjusted *VaR*, designated *LVaR*, can be expressed as:

$$LVaR = VaR + VaR_L. \quad (1)$$

The third step implies that *VaR* and VaR_L are perfectly correlated. This means in words, it assumes simultaneous occurrence of extreme events, which can lead to overestimating the risk. An alternative is to consider the correlation between the two components in the model. Considering the orientation of Solvency II of adopting a cautious approach, we do not reject the assumption of perfect correlation as exaggerated. It must not be forgotten that the endogenous component of liquidity risk is not being measured, which in itself results in underestimating the liquidity risk. Moreover, the use of simple addition in equation (1) means that all the computations currently accepted for measuring market risk need no modification; the component of liquidity risk is simply added. Bangia et al. (1999) measure liquidity risk (VaR_L) as:

$$VaR_L = \frac{1}{2}\left[P_t \cdot \left(\overline{S} - N^{-1}(\alpha) \cdot \overline{\sigma}\right)\right], \quad (2)$$

where $\overline{S}$ is the average of the *percentage quoted spread*, computed as:

$$\overline{S} = \frac{1}{n}\sum_{i=1}^{n}\frac{P_{Ask} - P_{Bid}}{P_{Mid}},$$

P_t is the average price of the asset at time t, and σ is the volatility of the percentage quoted spread and α is the factor that ensures the preferred confidence level for *VaR*. Equation (2) assumes that the percentage quoted spread follows a normal distribution.

2. Liquidity risk in the Portuguese insurance industry

In this Section we apply the model proposed by Bangia et al (1999) to evaluate liquidity risk in portfolio holdings of Portuguese insurance companies. All computations were performed based the portfolio holdings of 45 Portuguese insurance companies as published in their annual reports at the end of 2009. Of these companies, 15 dealt in life insurance (V), 23 in non-life, i.e. general, insurance (N), and seven of them in mixed, i.e. in both life and general, insurance (M).

As set out by the Solvency II regime, portfolios of assets where the investment risk is borne by the policy holder were excluded from analysis. We considered a confidence interval of 99,5% and a time frame of one year. Computation of conventional *VaR* follows a parametric approach based on assumptions similar to those in the latest quantitative impact study (QIS 5) for the evaluation of different market risks and global risk. *LVaR* is determined by the mean and standard deviations of the percentage quoted spread. Historic information on asset prices – the bid price, mid price and ask price – were obtained from Bloomberg's financial information terminal for the period of January 1, 2000 – March 15, 2010, making a total of 2661 observation days. The risk evaluation date was the March 15, 2010.

2.1. Portfolio holdings of the Portuguese insurance sector. We define the "market portfolio" of the insurance sector as all the assets held in the portfolios of the 45 insurance companies. Figure 1 shows the proportion of different assets in the market portfolio at the end of 2009.

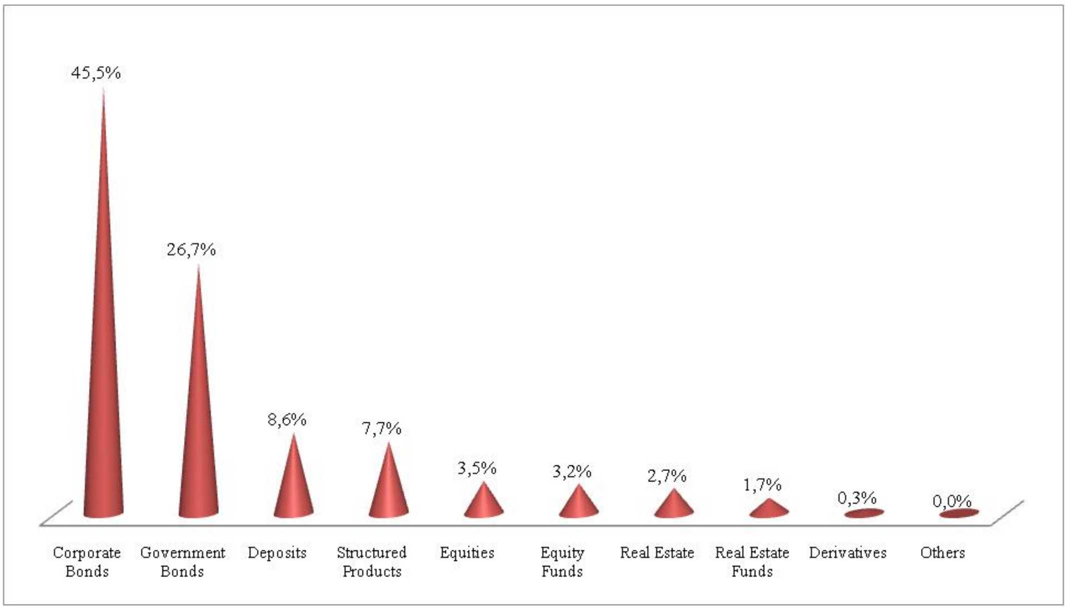

Fig. 1. Market portfolio allocation

Bonds and structured products account for 79,9% of the market portfolio. Corporate bonds make up the greatest share (45,5%), followed by government bonds (26,7%). An analysis by insurance company reveals distinct investment profiles coexist in the insurance sector (Figure 2), there are: (1) companies that invest almost exclusively or predominantly in government bonds – M6 (92%), V11 (79%), N2 (74%), and V1 (72%); (2) companies that invest heavily in corporate bonds, as well as structured products – N22 (77%), N17 (73%), N9 (73%), M1 (73%), N20 (72%), M2 (71%), and V4 (70%); (3) companies with some or significant exposure in the stock market – N6 (25%), N5 (16%) and N14 (15%); and (4) companies in which the real-estate sector accounts for a significant share – N8 (49%), N3 (35%), N7 (27%), and N5 (24%). Investments in structured products, which overall make up only 7,7% of the market portfolio, account for a significant share of the portfolio in some companies, namely M1 (36%), V5 (20%), N9 (20%), V10 (18%), and N21 (16%). Although investment in equity funds is not significant overall, two companies – N17 and M7 – hold investments of 25% and 18% respectively in their portfolios. Finally, there is a significant concentration level in the insurance market, which naturally impacts the composition of the market portfolio.

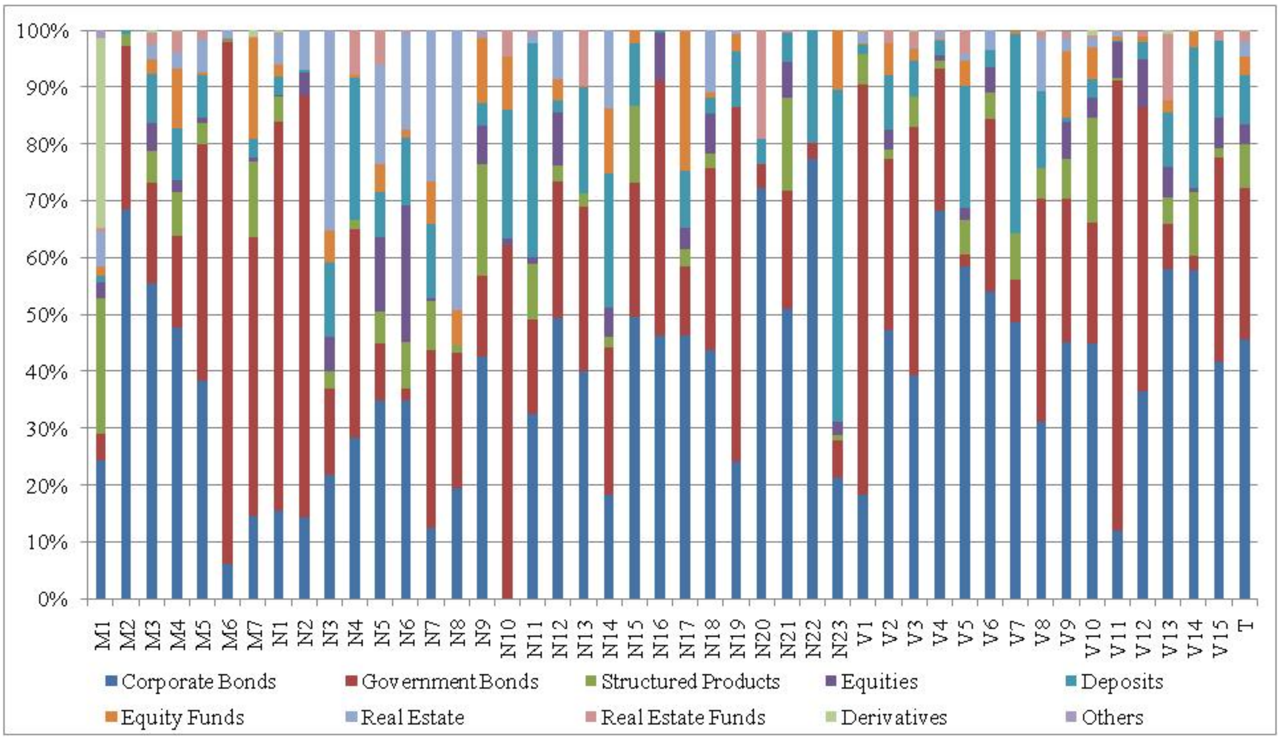

Fig. 2. Insurance undertakings asset portfolio allocation

Given the aims of this study and the relative share of each asset type, only the government and corporate bonds, structured products and equities were selected for analysis. This reduced set of assets will be referred to the "selected portfolio", and it made up 83,4% of the market portfolio holdings at the close of 2009. Furthermore, in order to ensure reliability and robustness for the results of the study, we used only assets for which there were a minimum of 10% of total possible observations for the period under analysis, or for which there were more than 100 observations from January 1, 2007. Figures 3 and 4 show the distribution of the observations. As a result of this procedure, 2.725 assets were subject to analysis, with a total of 3.110.931 observations, corresponding to an average of 1.142 (4,5 years) observations for each asset. The average for an asset, given as the ratio of observations to the number of days in which observation was possible in the period under study, is 93,2%. The 2.725 assets, which we shall call the "analysed portfolio", make up 81,2% of the selected portfolio, and 67,8% of the market portfolio. Figure 5 compares the market, selected and analysed portfolios. 53,6% of the analysed portfolio are corporate bonds (45,4% is in the financial sector) and 37,1% are government bonds.

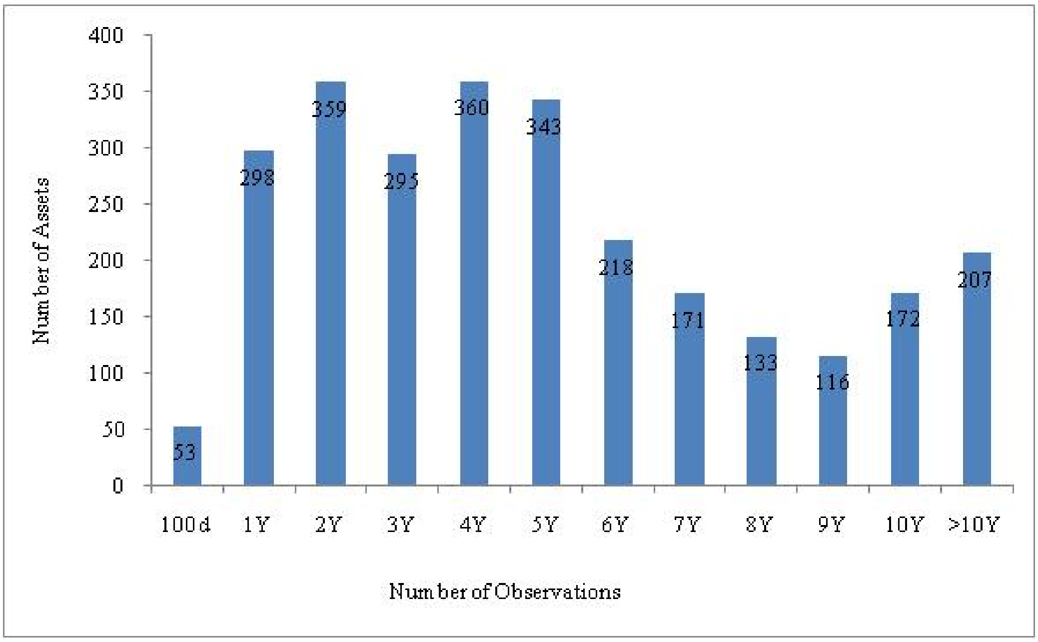

Fig. 3. Number of observations (years by asset)

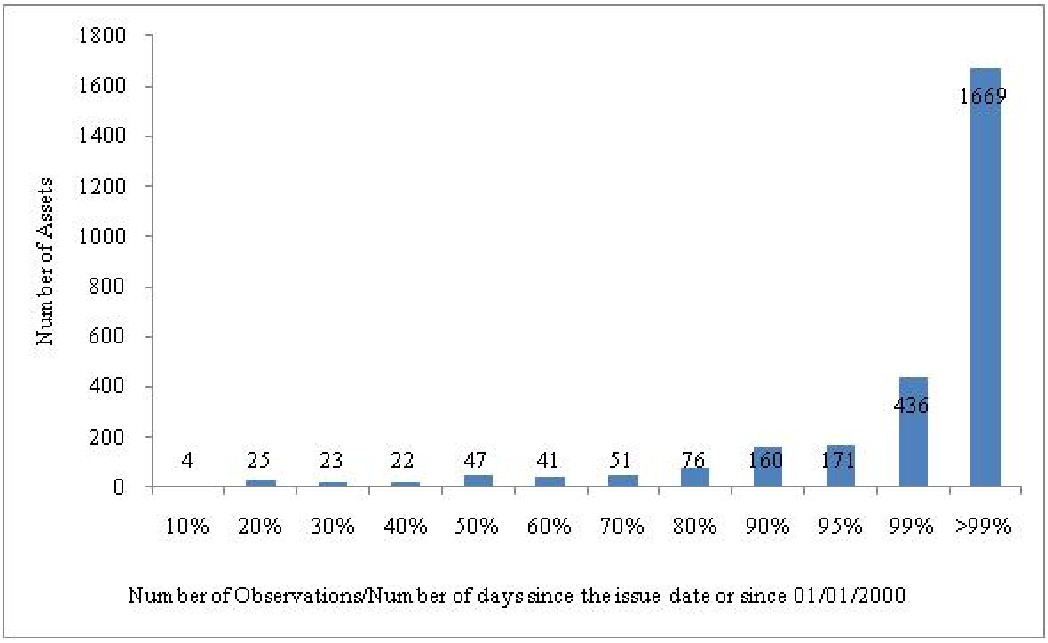

Fig. 4. Number of observations as a function of number of days (%)

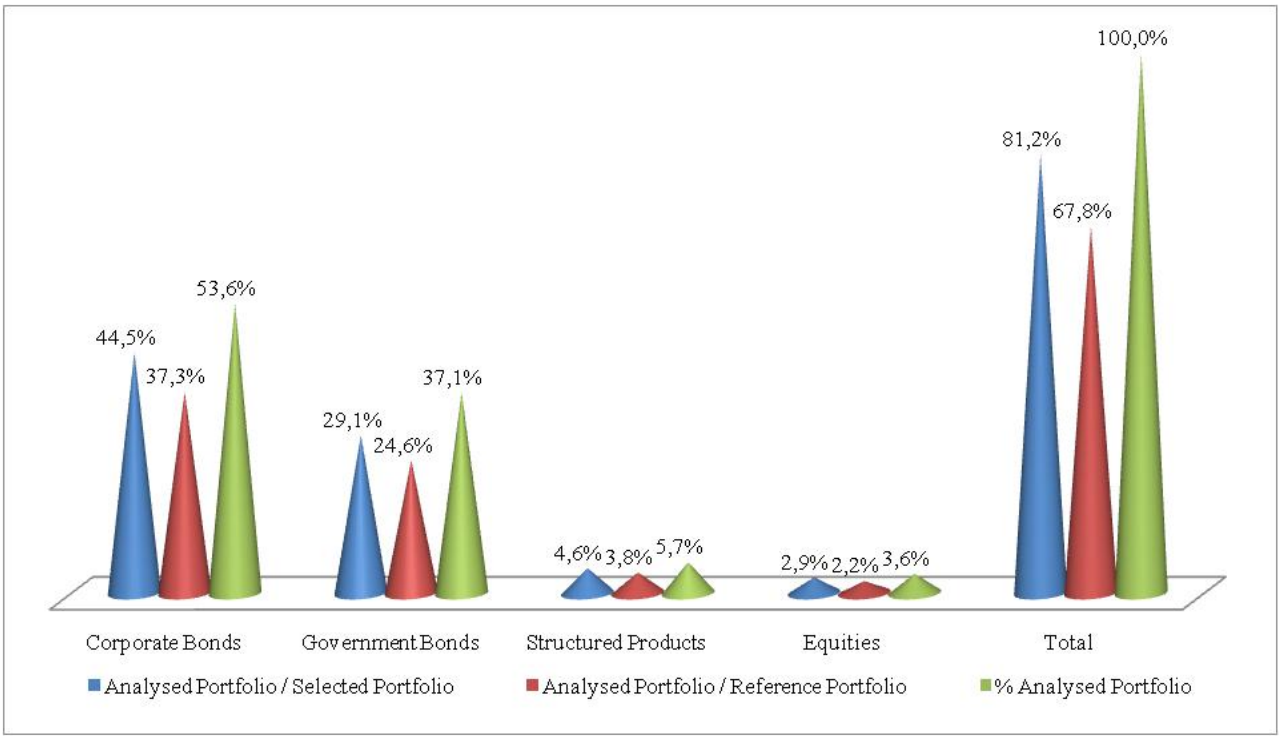

Fig. 5. Analysed portfolio asset distribution

The relative share of the analysed portfolio in the selected portfolio is, for the vast majority of the insurance companies, greater than 75%. Only six insurance companies are below this level, and of these, only three have an analysed portfolio of less than two thirds of the selected portfolio: M1 (66,7%), N5 (66,4%), V10 (66%), V7 (62%), N6 (43,9%), and N20 (33,4%) (see Figure 6). At the analysis date, the bond component has an average age of 4,3 years from the date of issue and an average maturity of 6,5 years. By contrast, the structured products have a high maturity date (17,4 years on average). The average bond rating is A. While corporate bonds show a rating similar to the average, government bonds have a rating closer to AA, and structured products ranged between A and BBB. The average rating was determined on the basis of grades by Standard & Poor's, Moody's and Fitch, and their evaluations were averaged. Ratings grades were rounded to the nearest tenth if necessary. The following numeric scale is used for the grades: AAA-1, AA-2, A-3, BBB-4, NR-5, and lower than BBB-6. Fixed coupon bonds make up 73,8% of the total fixed term assets, and the average coupon is 3,8% (see Table 1). Table A in the Appendix shows the same indicators for each insurance company's analysed portfolio.

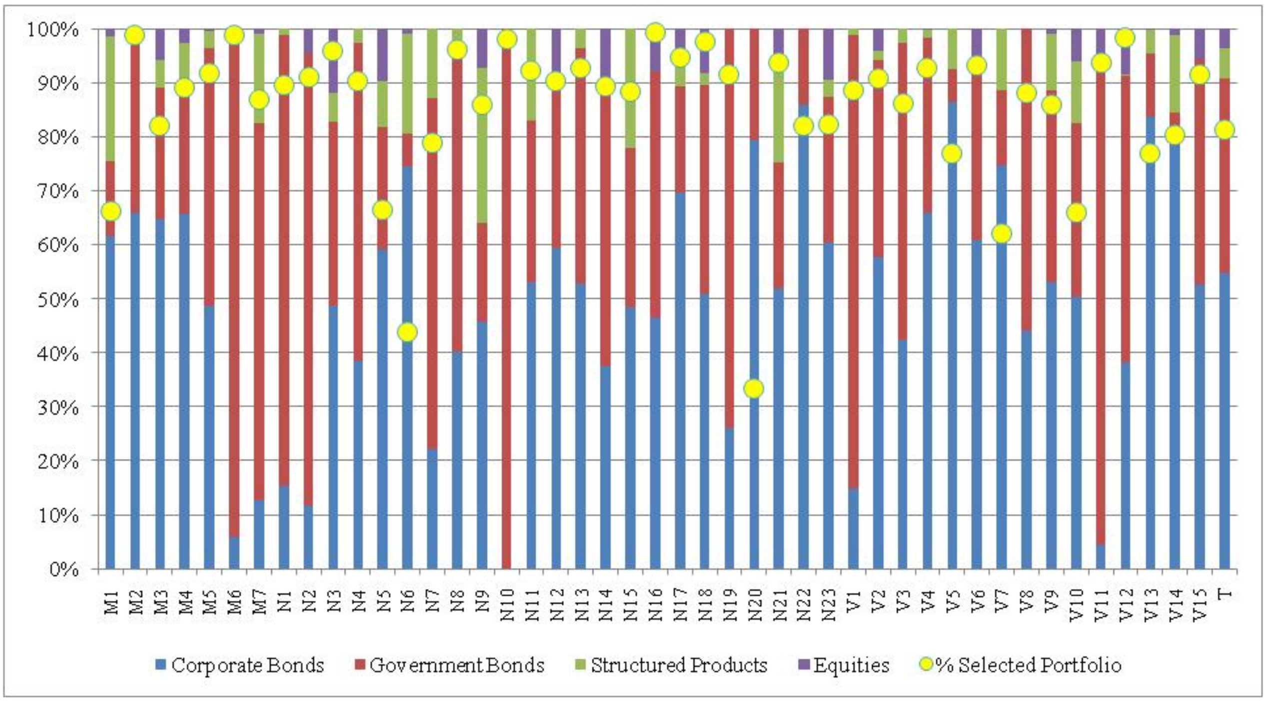

Fig. 6. Insurance undertakings' analysed portfolio risk allocation

Table 1. Analysed portfolio risk indicators

Indicators	Number of assets	Average years	Maturidade media	Average rating	Average coupon	% Financial sector	% Fixed coupon
Corporate bonds	1.760	3,8	5,1	2,8	4,0%	73,3%	69,0%
Goverment bonds	468	6,0	7,4	2,4	3,6%	n.a.	98,9%
Structured products	196	4,8	17,4	3,5	2,8%	95,4%	2,1%
Equities	301	n.a.	n.a.	n.a.	n.a.	18,9%	n.a.
Total	2.725	4,3	6,5	2,8	3,8%	45,4%	73,8%

2.2. Liquidity risk analysis. *2.2.1. Market portfolio liquidity risk.* Table 2 shows results for the distribution of individual observations of *VaR*, VaR_L, *LVaR*, and the relation between VaR_L and *LVaR*. The distribution of VaR_L, given as a percentage, shows an average of 0,6 percent above the mean (0,3%), indicating positive asymmetry. This is confirmed by the coefficient for asymmetry (9,3). The positive excess kurtosis measure (117,2) indicates a leptokurtic distribution. Standard deviation and variance show high concentration in their distributions, with figures of 1,7% and 0,03%, respectively. Analysis of the relative frequency of VaR_L by asset (see Figure 7) shows that 85% of the assets have a liquidity risk of less than 0,5%, and only 7,2% have a liquidity risk of more than 1%. The distributions of *VaR* and *LVaR*, given as percentages, are very similar; both show averages greater than the median. They also show positive asymmetry and the positive excess kurtosis measure indicates a leptokurtic distribution. Analysis of the distribution of the standard deviation and variance shows some dispersion, although 61,0% of the assets have a *VaR* and *LVaR* of less than 5%, and only 16,8% above 10% (see Figure 8). The distribution of the relation between VaR_L and *LVaR* shows an average of 30,3%, which is significantly greater than the median (7,4%). This positive asymmetry is confirmed by the asymmetry coefficient (1,0). The kurtosis measure (0,9) suggests a platykurtic distribution. The high values for the standard deviation (38,5%) and variance (14,9%) corroborate the highly dispersed distribution: 60,6% of the assets show a ratio below 10%, and at the other tail, 20,1% of the assets have a ratio above 90% (see Figure 9).

Table 2. Descriptive statistics: liquidity risk and market risk

Descrip. st.	*VaRL%*	*VaR%*	*LVAR%*	$VaR_L/LVaR$
Mean	0,59%	8,37%	8,96%	30,33%
Standard error	0,03%	0,29%	0,30%	0,74%
Median	0,29%	3,63%	3,98%	7,40%
Standard deviation	1,67%	15,32%	15,55%	38,48%
Variance	0,03%	2,35%	2,42%	14,80%
Kurtosis	117,19	8,13	7,89	-0,90
Skewness	9,28	2,88	2,83	0,97
Interval	34,5%	100,0%	100,6%	99,9%
Minimum	0,0%	0,0%	0,0%	0,1%
Maximum	34,5%	100,0%	100,6%	100,0%
Sum	16	228	244	826
Count	2.725	2.725	2.725	2.725
Confidence interval (95,0%)	0,06%	0,58%	0,58%	1,45%

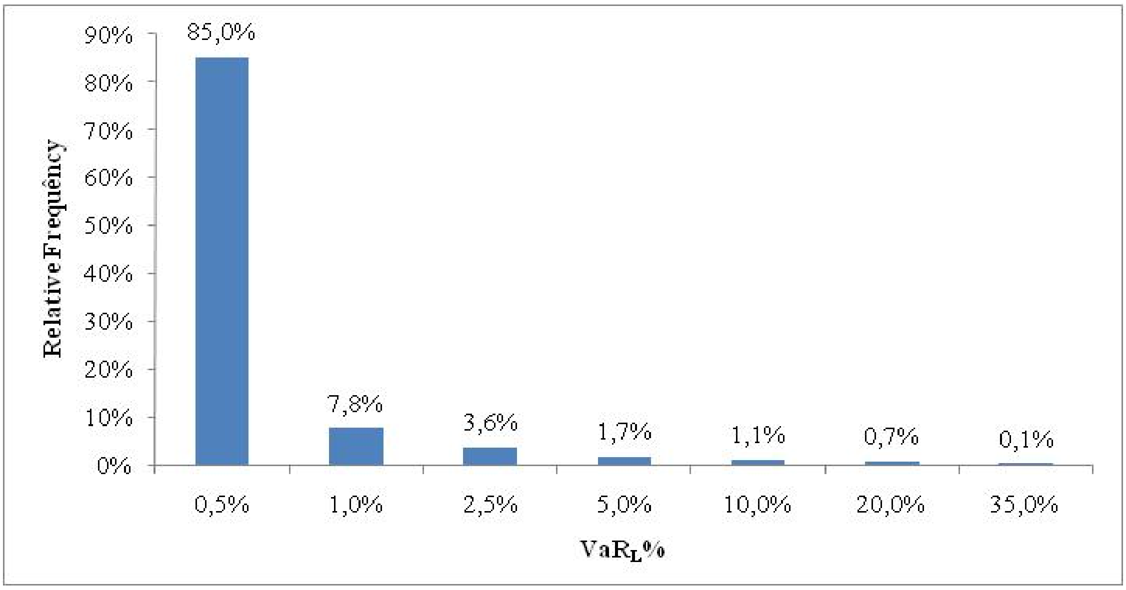

Fig. 7. Histogram of VaR_L% by asset

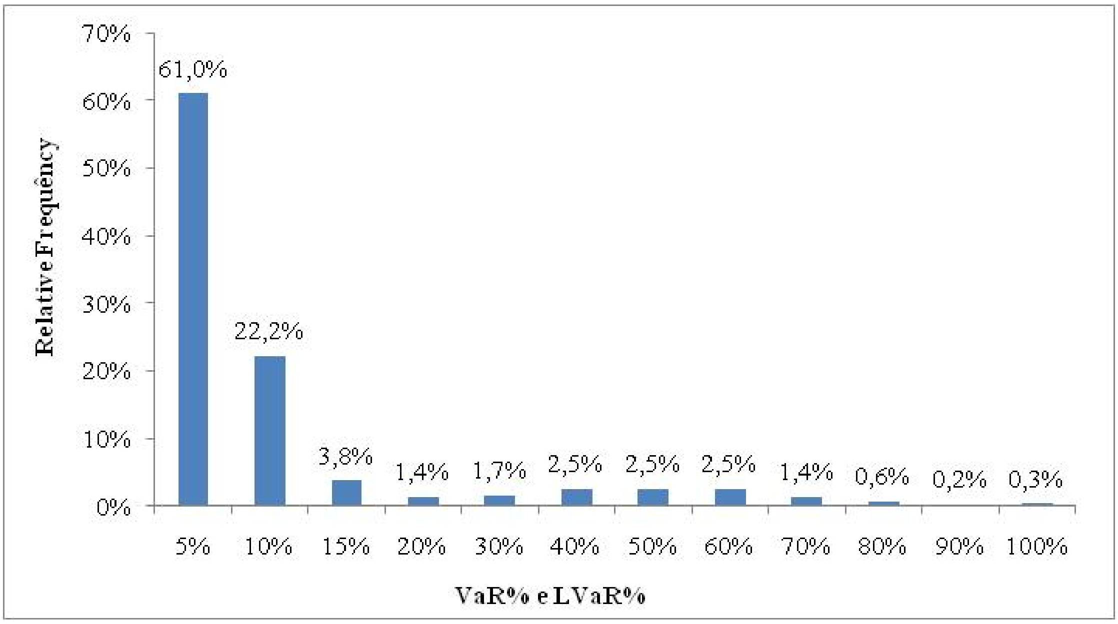

Fig. 8. Histogram of *VaR*% and of *LVaR*% by asset

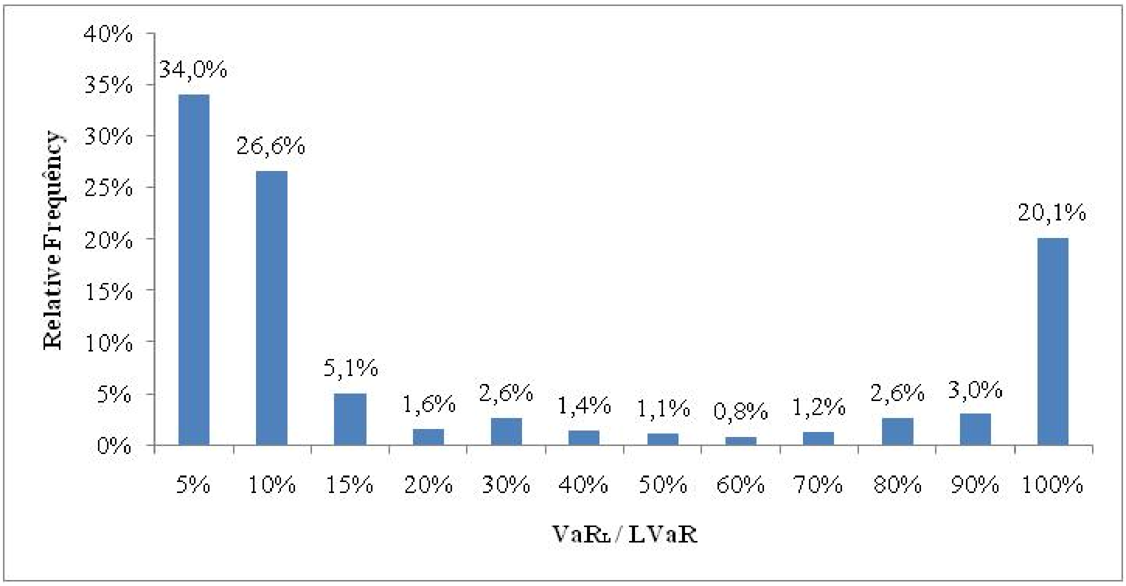

Fig. 9. Histogram of $VaR_L/LVaR$ by asset

An analysis of the liquidity risk according to asset class reveals that government bonds tend to have a lower risk (0,26%). This is to be expected. Structured products with an average VaR_L of 1,66% show the highest risk, surpassing equities, whose average value was 1,09%. Nonetheless, given that fluctuations in prices are only slight, the structured products have a lower average *VaR* and *LVaR* than the other assets. Equities, as expected, show the highest average *LVaR*, and government bonds, which have recently shown volatility in their prices, also show a higher *LVaR*. This is a result of the possibility of some European Union countries defaulting on their bonds (see Table 3).

Table 3. Liquidity risk and market risk: asset class type

Assets class type	Number of assets	% Analysed portfolio	Average			Standard deviation		
			VaR%	VaR_L%	*LVaR*%	*VaR*%	VaR_L%	*LVaR*%
Corporate bonds	1.760	53,6%	3,11%	0,47%	3,57%	3,11%	1,45%	3,50%
Government bonds	468	37,1%	6,60%	0,26%	6,86%	6,79%	0,68%	6,91%
Structered products	196	5,7%	1,79%	1,66%	3,45%	3,36%	3,67%	4,55%
Equities	301	3,6%	46,19%	1,09%	47,28%	19,07%	1,51%	19,09%
Total	2725	100%	8,37%	0,59%	8,96%	15,32%	1,67%	15,55%

Table 4. Liquidity risk and market risk: bond characteristics

Measures	Number of assets	% Analysed portfolio	Average			Standard deviation		
			VaR%	VaR_L%	*LVaR*%	*VaR*%	VaR_L%	*LVaR*%
Maturity interval								
[0-1[	345	11,9%	0,09%	0,28%	0,37%	0,22%	0,55%	0,59%
[1-3[	625	24,9%	1,58%	0,31%	1,89%	1,43%	0,46%	1,47%
[3-5[	521	22,8%	3,64%	0,45%	4,09%	2,14%	1,92%	2,86%
[5-7[	359	13,4%	3,96%	0,55%	4,52%	2,48%	1,46%	2,68%
[7-10[	262	11,6%	6,07%	0,65%	6,72%	3,81%	1,71%	3,77%
>10	312	11,9%	9,55%	1,20%	10,76%	7,34%	3,06%	7,27%
Rating								
AAA	486	18,3%	4,72%	0,25%	4,97%	4,45%	0,47%	4,45%
AA	409	17,6%	3,31%	0,52%	3,84%	3,85%	2,21%	4,43%
A	953	42,5%	2,92%	0,46%	3,38%	3,10%	1,24%	3,30%
BBB	395	12,4%	3,70%	0,73%	4,42%	4,49%	2,00%	4,88%
<BBB	60	0,5%	6,33%	1,89%	8,22%	9,98%	4,31%	100,5%
NR	121	5,2%	5,25%	0,80%	6,04%	6,81%	1,82%	7,10%
Coupon type								
Fixed	1.664	68,2%	4,47%	0,36%	4,83%	3,94%	1,25%	4,16%
Floating	522	18,7%	0,11%	0,86%	0,97%	0,80%	2,30%	2,50%
Variable	147	3,9%	4,88%	1,12%	6,00%	3,51%	2,83%	4,08%
Zero coupon	78	5,4%	6,81%	0,50%	7,31%	7,67%	0,98%	8,24%
Step coupon	7	0,2%	15,45%	1,62%	17,07%	22,30%	1,75%	23,83%
Flat trading	6	0,0%	9,30%	0,48%	9,77%	4,41%	0,13%	4,89%
Sector								
Financial	1.362	44,7%	2,51%	0,68%	3,19%	3,08%	2,15%	3,72%
Government	439	36,8%	6,67%	0,20%	6,88%	6,92%	0,57%	7,05%
Utilities	151	4,5%	4,64%	0,31%	4,94%	3,04%	0,34%	3,07%
Communications	117	3,0%	3,63%	0,33%	3,96%	3,48%	0,50%	3,52%
Consumer, non-cyclical	101	2,5%	3,99%	0,40%	4,39%	2,37%	0,74%	2,47%
Industrial	93	1,7%	4,88%	0,50%	5,38%	3,41%	1,18%	3,91%
Energetic	46	1,1%	4,37%	0,40%	4,76%	2,86%	0,45%	2,87%
Basic materials	49	1,0%	3,06%	0,37%	3,42%	1,97%	0,42%	1,90%
Consumer, cyclical	43	0,7%	2,91%	0,38%	3,29%	4,13%	0,32%	4,10%
Diversified activities	11	0,1%	4,83%	0,30%	5,13%	3,83%	0,09%	3,83%
Mortgages	10	0,0%	4,27%	2,45%	6,72%	3,82%	1,68%	4,67%
Technology	2	0,0%	0,80%	0,39%	1,18%	1,11%	0,07%	1,05%
Debt type								
Unsubordinated	2.052	87,3%	3,75%	0,36%	4,11%	4,44%	1,18%	4,62%
Subordinated	372	9,2%	3,24%	1,42%	4,66%	3,83%	3,12%	4,69%

In view of relative share of the bonds and structured products within the insurance companies' portfolios, we sought to identify the determinants of liquidity risk for the portfolios. To this end we analysed liquidity risk in terms of maturity, rating, volatility, number of years since issue, coupon type, coupon value, activity sector, and the type of debt (see Table 4). Analysis of liquidity risk by maturity intervals revealed that the average VaR_L increased as maturity lengthened, and the value was significantly higher for bonds whose capital payment was longer than 10 years. *VaR* showed similar behavior. In terms of ratings, the average values show that liquidity risk grows as the credit quality declines, with steeper growth for below investment grade status bonds. The average *VaR* is also higher for these bonds, as is the case for non-rated bonds. However, contrary to what is expected, the average *VaR* value for the highest rated bonds is above the mean. This is due to the impact of recent volatility on government bonds, which have higher credit ratings. Analysis by coupon type shows that fixed coupon bonds have below average liquidity risk, followed by zero coupon bonds. However, when both risk components are considered, floating coupon bonds show the lowest adjusted market risk due to their low *VaR* average. The other bonds show higher liquidity risk as they are less attractive from the point of view of return on the investment. Analysis by sector reveals that exposure to financial and industrial areas increases liquidity risk while exposure to the utilities and communications sectors mitigates it. With regard to *VaR*, however, apart from the government sector previously described, the utilities show an increase in market risk. Finally, subordinated debt products show above average liquidity risk although their *VaR* is slightly lower in comparison with the other bonds.

2.2.2. Liquidity risk by insurance company. The results of the analysis by insurance company show that on average liquidity risk accounts for around 10,28% of total adjusted market risk (see Table 5). The mean values for *LVaR* and VaR_L for a time interval of one year at a confidence level of 99,5% are 4,34% and 0,38% respectively.

Table 5. Liquidity risk and market risk: descriptive statistics

Value-at-risk	Mean	Median	Minimum	Maximum	Std. dev.
VaR%	3,96%	4,11%	1,32%	7,21%	1,53%
VaR_L%	0,38%	0,32%	0,12%	1,46%	0,25%
LVaR%	4,34%	4,34%	1,80%	7,33%	1,47%
$VaR_L/LVaR$	10,28%	7,46%	1,69%	38,49%	8,26%

Table 6 shows an interval analysis for the companies. There is greater dispersion amongst the operators for *VaR* despite greater concentrations in the interval 3%-4,5%. Two companies stand out at the outer edges: a life insurance company (V7) with a minimum of 1,3%, and a mixed insurance company (M6) with a maximum of 7,2%. In view of the high relative share of *VaR* in *LVaR*, we note that 68,9% of the insurance companies have an adjusted market risk between 3,0% and 6,0%. Further, in 40% of the companies, liquidity risk accounts for more than 10% of total market risk.

Table 6. Insurance undertakings: interval analysis for *VaR*%, VaR_L%, *LVaR*% and $VaR_L/LVaR$

VaR%	Life and general	General	Life	Total	VaR_L%	Life and general	General	Life	Total
[0,00% - 1,50%[	-	-	1	1	[0,00% - 0,25%[	1	8	5	14
[1,50% - 3,00%[	3	5	4	12	[0,25% - 0,50%[	6	11	7	24
[3,00% - 4,50%[	1	10	5	16	[0,50% - 0,75%[	-	1	2	3
[4,50% - 6,00%[	1	7	4	12	[0,75% - 1,00%[	-	1	1	2
[6,00% - 7,50%]	2	1	1	4	[1,00% - 1,50%]	-	2	-	2
LVaR%	Life and general	General	Life	Total	$VaR_L/LVaR$	Life and general	General	Life	Total
[0,00% - 1,50%[	-	-	-	-	[0,00% - 5,00%[	1	5	3	9
[1,50% - 3,00%[	1	4	4	9	[5,00% - 10,0%[	3	10	7	20
[3,00% - 4,50%[	3	9	5	17	[10,0% - 20,0%[	3	5	4	12
[4,50% - 6,00%[	-	9	5	14	[20,0% - 30,0%[	-	2	-	2
[6,00% - 7,50%]	3	1	1	5	[30,0% - 40,0%]	-	1	1	2

Figure 10 shows the relation between liquidity risk and market risk for each insurance company. Of the companies for whom the relative share of liquidity risk in the adjusted market risk is greater than 10%, only five have *VaR* greater than 3%. Of these, N5 shows the highest figure (4,4%). On the other hand, only three of these operators have an adjusted market risk where both components are above 4%: N5, N21 and V10 have a *LVaR* of 5,6%, 4,03% and 4,02% respectively. Thus, it can be concluded that liquidity risk is an important component in the adjusted market risk of the insurance companies' analysed portfolios, despite the fact that most companies' *VaR*, and consequently *LVaR*, are below the market average.

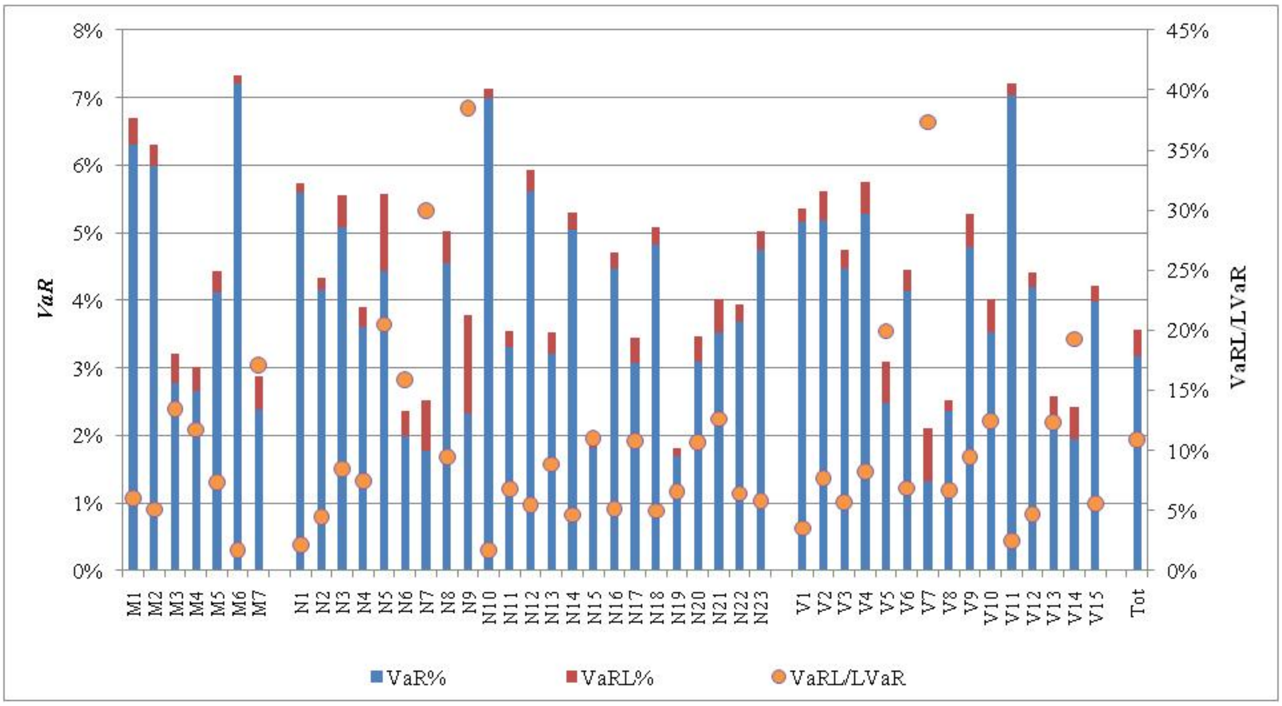

Fig. 10. Liquidity risk vs. market risk (by insurance company)

Conclusion

The purpose of this study was to use liquidity risk to quantify market risk and to help to determine the consequent capital requirements in accordance with the Solvency II Directive. To do so we wanted to use a simple method that would make use of easily available information and that would require no alterations to the methodologies already used to quantify conventional market risks. The method proposed by Bangia et al. (1999) provided us with such a tool as it uses bid/ask spread information and makes use of simple addition.

We applied the method to the portfolio holdings of 45 Portuguese insurance companies, which are subject to supervision by the Instituto de Seguros de Portugal (Portuguese Insurance and Pension Funds Supervisory Authority) using data from the close of the 2009 financial year. From the results obtained for a time interval of one year and a confidence level of 99,5%, it was found that on average, liquidity risk per operator was around 0,4%, and it accounted for 10,3% of the total adjusted market risk. In 40% of the insurance companies liquidity risk was greater than 10% of the total adjusted market risk, even though most of these insurance companies showed a below market average *VaR*.

The results of this study are limited by the fact that only quoted financial assets for which information was available and consistent were used. As a result, it is highly likely that both liquidity risk and market risk have been underestimated. It is possible to adjust the liquidity of these assets by applying linear regression models, which are estimated in function of the characteristics and indicators of a group of bonds and financial instruments – market benchmarks – that are defined for each class of asset. Even though underestimated, the values found by means of this empirical analysis of the Portuguese insurance sector clearly indicate that it is worthwhile to include liquidity risk in the measurement of market risk.

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Appendix

Table A. Analysed portfolio indicators by insurance company

Insurance company	Number of assets	Benchmark portfolio (%)	Average years	Average maturity	Average rating	Average coupon	% Fixed coupon	% Financial sector
M1	181	1,6%	1,3	6,8	1,3	1,8%	59,8%	50,1%
M2	271	2,4%	3,6	5,1	1,8	3,2%	95,3%	27,0%
M3	753	29,1%	6,6	6,5	4,2	5,0%	61,7%	59,4%
M4	403	4,7%	3,0	3,3	2,1	2,7%	58,3%	59,2%
M5	195	2,9%	1,9	3,3	1,2	2,0%	89,5%	32,6%
M6	19	1,3%	0,3	0,3	0,1	0,2%	100,0%	1,1%
M7	103	1,5%	1,7	1,4	0,9	0,8%	78,2%	27,4%
N1	91	0,6%	1,5	1,3	0,5	0,9%	94,6%	15,1%
N2	109	1,9%	1,3	1,0	0,6	1,0%	95,4%	9,0%
N3	65	0,0%	0,5	0,9	0,4	0,4%	69,2%	26,8%
N4	92	0,4%	1,1	1,3	0,6	0,8%	79,0%	40,2%
N5	333	0,6%	2,5	3,6	1,9	1,4%	53,5%	50,5%
N6	97	1,1%	0,6	1,3	0,7	0,7%	48,2%	54,7%
N7	61	0,1%	0,7	1,1	0,4	0,5%	67,5%	30,9%
N8	51	0,1%	0,7	1,5	0,3	0,6%	90,7%	35,1%
N9	69	0,1%	0,4	0,9	0,4	0,4%	48,1%	57,4%
N10	12	0,3%	0,1	0,2	0,1	0,1%	100,0%	0,0%
N11	120	0,1%	1,2	1,4	0,9	0,8%	54,6%	54,6%
N12	180	1,7%	1,8	2,2	1,0	1,7%	88,8%	30,1%
N13	58	0,1%	0,7	0,8	0,3	0,5%	71,0%	56,4%
N14	72	0,1%	0,3	0,3	0,2	0,3%	77,6%	37,9%
N15	37	0,3%	0,2	0,4	0,2	0,3%	55,4%	40,2%
N16	92	0,2%	0,8	0,9	0,4	0,7%	91,9%	36,5%
N17	212	0,2%	1,6	1,7	1,1	1,3%	49,3%	63,5%
N18	168	0,5%	0,9	1,8	0,9	1,6%	84,1%	43,4%
N19	34	0,3%	0,4	0,2	0,2	0,3%	94,1%	26,0%
N20	10	0,0%	0,2	0,2	0,1	0,1%	74,6%	79,3%
N21	144	0,1%	0,8	1,1	0,6	0,8%	46,4%	59,1%
N22	20	0,0%	0,1	0,2	0,2	0,2%	100,0%	35,5%
N23	56	0,0%	0,3	0,5	0,4	0,5%	70,3%	39,1%
V1	134	0,9%	2,4	2,1	0,7	1,4%	93,3%	15,5%
V2	113	0,4%	0,9	1,5	0,5	1,0%	93,5%	34,4%
V3	311	16,7%	3,3	5,0	2,1	3,0%	87,9%	36,2%
V4	186	1,6%	2,1	3,7	1,1	1,9%	92,4%	43,6%
V5	132	0,7%	0,6	1,5	0,9	0,9%	77,3%	67,6%
V6	532	4,1%	5,6	6,8	2,7	5,3%	94,3%	34,9%
V7	193	3,8%	1,9	3,3	1,5	1,2%	44,6%	66,0%
V8	114	0,8%	1,3	1,2	0,6	0,9%	69,0%	44,1%
V9	256	1,3%	2,8	5,3	1,7	2,8%	80,1%	41,3%
V10	555	11,1%	3,9	9,0	3,5	4,5%	68,4%	51,1%
V11	123	1,5%	1,3	1,8	0,6	1,0%	93,2%	3,2%
V12	399	2,9%	2,2	2,8	2,0	3,0%	82,1%	25,4%
V13	270	0,9%	3,3	2,2	2,0	3,1%	86,0%	54,6%
V14	99	0,9%	0,6	1,4	0,7	0,8%	52,3%	47,1%
V15	87	0,2%	0,3	0,8	0,4	0,8%	90,7%	42,9%
Average	169	2,2%	1,6	2,2	1,0	1,4%	76,7%	40,6%
Stand. Dev.	156	5,1%	1,4	2,1	0,9	1,3%	17,3%	18,0%