Initial Margins for Interest Rate Derivatives

Paul du Preez and Antonie Kotzé

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1. Introduction

The aim of this document is to give a brief review of the methodology currently being used to calculate the IMRs for fixed income derivatives. We will highlight the weaknesses of the current methodology, and propose amendments that can be made to overcome these weaknesses.

2. The Current Methodology

When calculating the initial margin requirements (IMRs) for a particular futures contract, the JSE assumes that the log-return process for that contract follows a normal distribution. Then, once the parameters of the normal distribution have been calibrated, the IMR is calculated as:

$$\mathrm{IMR} = \mathrm{V} \times [\exp\{\Phi^{-1}(0.5[1+\alpha])\sigma\} - 1] \times \sqrt{\mathrm{N}}, \tag{1}$$

where:

- V is the current mark-to-market (MTM) value of the particular contract,
- σ is the standard deviation of the fitted normal distribution,
- Φ^{-1} is the inverse cumulative normal distribution function,
- α is the confidence level,
- N is the holding period.

Currently we use 2001 simulated mark-to-market levels for bond futures and also 2001 historical daily mark-to-market levels for bond indices when fitting the normal distribution, i.e. 2000 daily returns.

Currently the JSE uses a risk parameter of 3.5 standard deviations corresponding to a confidence level of 99.95%. The chance that larger moves will occur in practice - which means that margins will be insufficient to cover losses - is, at 3.5 standard deviations and under the assumption of log normality, 1 in 2,000 in any day, and 1 in 9 over a whole year.

Safcom's holding period is set at one day across all markets. However, some international clearing houses like LCH[1] and OMX[2] changed their holding periods to at least two days. In a note addressed to Safcom, Rand Merchant Bank notes [RMB 12]: *"Implicit in this 1-day holding period are the assumptions that the clearing member bank recognises a margin shortfall, settles the margin dispute with the client, calls default and exits or hedges the position in that one day. Historical experience has shown that this process takes longer than one day."*

Further to this, the OMX margin methodology states that [OMX 12]:
"However, under normal conditions an account cannot be closed at the instant a participant defaults at the prevailing market prices. It typically takes time to neutralize the account and the value of the account can change during this period, which must be catered for in the margining methodology…. Since neutralizing an account in a default situation can take time, there is a lead-time from the moment default occurs to the time at which NASDAQ OMX Derivatives Markets is able to close the participant's positions and when necessary, liquidate the collateral that has been pledged. It is conservatively assumed that it takes two days on average to close counterparty's positions and liquidate related collateral in the event of a default. For this reason, the margin parameters are calculated with a two-day lead-time factored into the methodology."

3. The Assumption of Normality

Academics and practitioners have for decades been questioning whether the normal distribution actually provides a good fit to the log-return process [HW 98]. *Figure 1* shows the empirical log-return distribution of the R157 government bond against the fitted normal distribution. Under a 99.95% confidence level, the normal distribution predicts that an IMR breach should occur once in every 2000 observations. However, the empirical distribution shows that an IMR breach occurs approximately twice every year. Clearly, the assumption of normality is grossly violated.

In *Figure 2* we give further evidence to the non-normality of the R157 bond. We show a Q-Q plot of the sample data. This clearly shows that the distribution is leptokurtic with heavy tails. A heavy tailed Q-Q plot has an S shape. Heavy tailed populations are symmetric, with more members at greater remove from the population mean than in a normal population with the same standard deviation. To compensate for the extreme members of the population, there must also be higher concentration around the population mean than in a Normal population with the same standard deviation. That is, heavy tailed populations also have higher, narrower peaks than the benchmark normal population. Hence the term leptokurtic - narrow arched.

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[1] http://www.lchclearnet.com/images/lch%20clearnet%20ltd%20-%20initial%20margin_tcm6-44535.pdf
[2] http://nordic.nasdaqomxtrader.com/digitalAssets/80/80606_marginmethodology120612.pdf

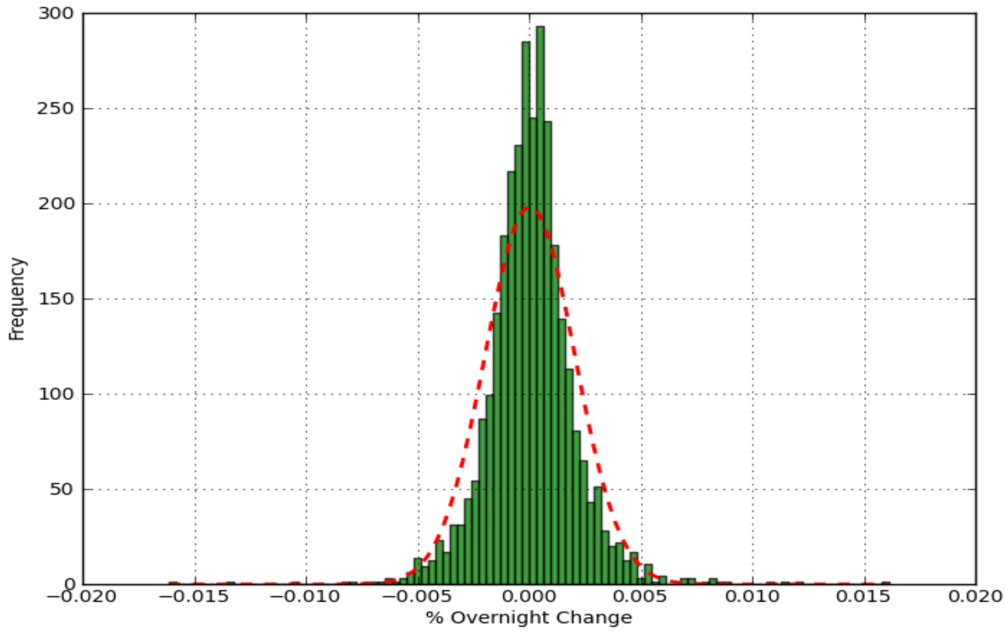

Figure 1: Empirical log-return distribution of the R157 against a fitted normal distribution.

4. The Proposed Methodology

4.1 Historical Simulation

As discussed in the previous section, many markets return data show fatter tails than the normal distribution. This led risk managers in making use of empirical distributions for estimating Value at Risk (VAR) measures. Such methods are often referred to as historical simulation. As noted by Hull and White [Hu 98]: *"Historical simulation involves creating a database consisting of the daily movements in all market variables over a period of time. The first simulation trial assumes that the percentage changes in the market variables are the same as on the first day covered by the database; the second simulation trial assumes that they are the same as on the second day; and so on. The change in the portfolio value is calculated for each simulation trial and the required percentile of the probability distribution of this change is estimated. As an example, suppose that 1,000 days of data are used and the 1 percentile of the distribution is required. This would be estimated as the tenth worst change in the portfolio value."*

In order to overcome the abovementioned problem, the JSE proposes that historical simulation be used for calculating the initial margins on all fixed income futures. *Table 1* illustrates how the current IMRs would change under a historical simulation, with the assumption of a 1-day holding period, and a 99.95% confidence level still applicable.

Sample Size	Critical Value Using a = .01	Critical Value Using a = .05	Critical Value Using a = .10
2000	0.995123684	1.003114382	1.003850445
r Correlation Coefficient	Conclusion Using a=.01	Conclusion Using a=.05	Conclusion Using a=.10
0.9661649	Sample data do not support the claim that these values come from a normal population.	Sample data do not support the claim that these values come from a normal population.	Sample data do not support the claim that these values come from a normal population.

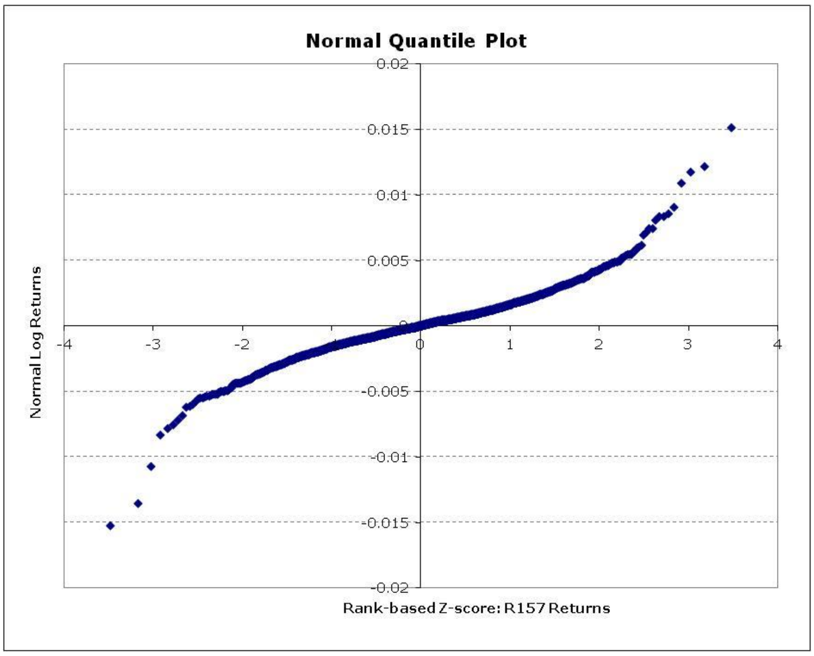

Figure 2: Normal quantile or Q-Q plot for R157. Above the plot is an analysis. This clearly shows that the data is not normally distributed but are leptokurtic.

Underlying	Asset Class	Current IMR	Breaches P/A	IMR Under HS	Breaches P/A
R157	Fixed Income	880	2.25	2000	0.125
R186	Fixed Income	2260	1.5	3280	0.125
R209	Fixed Income	2980	0.125	2870	0.125
ALBI	Fixed Income	51300	1.25	68950	0.125

Table 1: Summary of how the JSE's current IMRs would change under a historical simulation, with $\alpha = 99.95\%$, *and* $N = 1$.

4.2 The Confidence Level

Initial margin is intended to act as the first line of defense against protecting the capital of the default fund under normal market conditions. The question that needs to be asked is then what constitutes normal market conditions. The answer to this question is subjective, and likely to be the topic of some dispute. However, in accordance with the practices of various international Central Clearing Parties (CCPs), the JSE proposes considering a normal market condition as a condition that prevails 99.7% (which under the assumption of normality is equivalent to 3 standard deviations) of the time. Accordingly, the JSE proposes using a 99.7% confidence level for calculating initial margins. *Table 2* illustrates how the some of the current interest rate IMRs would change under a historical simulation, with a confidence level of 99.7%, and a holding period of 1-day.

Underlying	Asset Class	Current IMR	Breaches P/A	IMR Under HS	Breaches P/A
R157	Fixed Income	880	2.25	1300	0.75
R186	Fixed Income	2260	1.5	2490	0.75
R209	Fixed Income	2110	1.125	2280	0.75
ALBI	Fixed Income	51300	1.25	53360	0.75

Table 2: Summary of how the JSE's current IMRs would change under a historical simulation, with $\alpha = 99.7\%$*, and* $N = 1$*.*

4.3 The Holding Period

The holding period used when calculating IMRs must take cognisance of the economics of the particular contract – see section 2. In accordance with the concerns expressed with regards to a 1-day holding period, the JSE proposes a holding period of 2-days for all fixed income futures.

Note, common practice when estimating an N-day VaR is to simply multiply the 1-day VaR by the square root of N. Unfortunately, this rule is unreliable, and can lead to considerable overestimates of VaR [BI 02]. In order to avoid this problem, we propose using the α percentile of the database consisting of N-day changes in a particular market variable, over a certain period of time. For a two day holding period this means we will use two day returns or returns calculated by using today's MtM and the MtM from the day before yesterday.

Table 3 illustrates how the current IMRs would change under a historical simulation, with a confidence level of 99.7%, and a holding period of 2-days. Clearly, by increasing the holding period, we significantly increase the IMRs. Hopefully, these increases would be sufficient for the exchange margin to become the trusted market rate used by all participants, with possible adjustments made by clearing members for client credit risk[3].

Underlying	Asset Class	Current IMR	Breaches P/A	IMR Under HS	Breaches P/A*
R157	Fixed Income	880	2.25	1990	0.75
R186	Fixed Income	2260	1.5	3590	0.75
R209	Fixed Income	2110	1.125	3220	0.75
ALBI	Fixed Income	51300	1.25	81870	0.75

Table 3: Summary of how the JSE's current IMRs would change under a historical simulation, with $\alpha = 99.7\%$*, and* $N = 2$*.*

5. Options and Can-Do's

The initial margin for any option listed on the JSE is determined by:

1. Calculating the change in the value of the option over a 1-day horizon, under an array of possible scenarios for the price, and volatility of the underlying asset.
2. Calculating the worst possible change in value for the option, under the given array of scenarios. The initial margin for the option is then set equal to this worst possible change.

The JSE proposes that the holding period for any option be equal to the holding period assumed for the underlying asset. The effect of this would be more conservative initial margins for options on fixed income futures. Note, the JSE has started a process of updating the IMRs for can-do derivatives on a frequent basis (instead of once of, at inception). This practice should ensure that at all times, the appropriate amount of initial margin is charged for all can-do derivatives.

6. Conclusion

The key to improving the risk estimation practices of the JSE lies in changing the methodology behind the IMR calculation. The JSE proposes that the initial margins for all fixed income futures be calculated using historical simulation, with a 99.7% (which under the assumption of normality is equivalent to 3 standard deviations) confidence level. Furthermore, we propose a holding period of 2-days for all fixed income derivatives.

[3] Note, under historical simulation, the number of breaches per annum is measured on an N-day basis.

Table 4 provides a summary of the proposed IMRs, and illustrates what the SAFEX risk parameter would have to be (under the current methodology) to arrive at the same number[4].

Underlying	Current IMR	Proposed IMR	Confidence Level	Holding Period	Implied Risk Parameter
R157	880	1990	99.7%	2-days	7.9
R186	2260	3590	99.7%	2-days	5.52
R209	2110	3220	99.7%	2-days	5.3

Table 4: Proposed JSE IMRs under historical simulation.

References

[Bl 02] D. Blake and A. Cairns and K. Dowd. *Extrapolating VaR by the square-root rule*. *Financial* Engineering News, pp 3-7, August 2000.

[Hu 98] J.C. Hull and A. White. *Incorporating volatility updating into the historical simulation method for Value at Risk*. Journal of Risk, 1(1), pp 5-19,1998.

[RMB 12] Rand Merchant Bank. *SAFEX Margin Discussion Document*. SAFCOM Advisory Committee, April 2012.

[OMX 12] NASDAQ OMX, *Margin Methodology*, 12 June 2012, http://nordic.nasdaqomxtrader.com/digitalAssets/80/80606_marginmethodology120612.pdf

[4] The implied risk parameter represents the value of $\Phi^{-1}(\alpha)$, required to replicate the proposed IMR number, under the current methodology.