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Abstract

After reviewing the notion of Systemically Important Financial Institution (SIFI), we propose a first principles way to compute the price of the implicit put option that the State gives to such an institution. Our method is based on important results from Extreme Value Theory (EVT), one for the aggregation of heavy tailed distributions and the other one for the tail behavior of the Value-at-Risk (VaR) versus the Tail-Value-at-Risk (TVaR).

We show how to value in practice is proportional to the VaR of the institution and thus would provide the wrong incentive to the banks even if not explicitly granted. We conclude with a proposal to make the institution pay the price of this option to a fund, whose task would be to guarantee the orderly bankruptcy of such an institution. This fund would function like an insurance selling a cover to clients.

Keywords: Systemic Risk; "Too Big to Fail"; Risk Measure; Value-at-Risk and Tail Value-at-Risk; Option Price; Risk Neutral Distribution; Heavy tail; Pareto; Insurance

1 Introduction

In April 2009, the Financial Stability Board gave a definition of systemic risk in a report to the G20 ([3]): *"a risk of disruption to financial services that is caused by an impairment of all or parts of the financial system and that has the potential to cause serious negative consequences for the real economy."* This definition paved the way to qualify a certain number of financial institutions to be SIFI's (Systemically Important Financial Institution). Since then 20 international banks have been designated to be SIFI. Among them, there are Citibank, JP Morgan, Barclays, HSBC, Deutschebank, BNPParibas, Société Générale, UBS, Credit Suisse all big names of the banking industry. The banking regulation is in place with Basel II and applies to all banks. However, the debate is still open to how would the regulation be adapted to the SIFI's. Proposals are made to tighten the capital requirements and the supervisory process for these institutions. The academic literature has made few attempts to analyse the market to detect differences in valuation between normal banks and SIFI's [8, 4, 5]. Others have shown that financial innovations and microprudential regulations can produce instabilities in the market [1] and thus insist on a better approach to regulation of large financial institutions.

By qualifying a bank as SIFI, the State implies that he might bailout this company in case of difficulties to avoid the collapse of the financial system. In other words, he offers the SIFI an implicit put option in case of bankruptcy. The idea of SIFI designation came after the crisis of 2008/09 to make the system safer by avoiding the failure of critical actors of the financial markets. Paradoxically, offering such an umbrella to a financial institution whose goal is to maximize its profit, might end up incentivizing this company to take more risk in order to increase its return on equity. The regulators, conscious of this fact, wants the SIFI to hold a higher capital ratio than a normal bank (between 10.5 to 12.5% instead of 8%). Unfortunately, this capital will remain in the bank and will be based on the institutions own risk assessment.In order to ensure a system with a fair valuation of the risk taken by financial institutions, it would make sense to value the implicit put option offered by the State with the SIFI designation and ask the companies to pay it as an insurance premium.

This paper is about valuing the price of the implicit option the State is offering the banking institution when it qualifies it as a SIFI. The price of an option is defined as the expected payoff of this option times the probability of this payoff. We will determine these two variables in the following sections.

2 methodology

Let us consider a financial institution whose value can be expressed in terms of the economical value of its assets A and liabilities B, described by two stochastic processes $A = (A_t)_{t\geq 0}$ and $B = (B_t)_{t\geq 0}$ defined on a probability space $(\Omega, \mathcal{A}, I\!P)$. The value of the institution is then described by the stochastic process $(V_t)_{t\geq 0}$ with $V_t = A_t - B_t$ and its loss by $(L_t)_{t\geq 0}$ with $L_t = -V_t$. We will denote by $L_{\Delta t}$ the loss on time horizon Δt: $L_{\Delta t} = -(V_{t+\Delta t} - V_t)$.

Let r be the interest rate. At time $t_0 = 0$:

- the value of the company is given by $V_0 = A_0 - B_0$;
- its required (Solvency) capital is defined as $C_0 = e^{-r\Delta t}\, VaR_\beta(L_{\Delta t})$, Δt being 1 day or 10 days for a bank, and 1 year for an insurance company and $\beta = 99\%$ for banks and 99.5% for insurance;
- the Solvency ratio is given by V_0/C_0.

Suppose this institution is qualified by the regulators as a SIFI - Systemically Important Financial Institution- defined as an institution whose failure might trigger a financial crisis. This implicitly means that the State will not allow it to default and will have to cover its losses beyond the Solvency Capital of this institution. This is nothing else than a taxpayer put option on the value of the bank.

For simplicity, we assume that the Solvency ratio of this institution is 1 and measured for 1 year ($\Delta_t = 1$). Solvency being defined over a year,we will consider the maturity of this option as one year.

In Figure 1, we set the frame for this put option, saying to which value corresponds the strike price. In this figure, we also define the risk neutral probability q that the institution will survive 1 year. Obviously, the strike price, k, is the capital the company has at time t_0 discounted to

$$
\begin{array}{ccc}
\mathbf{t_0 = 0} & & \mathbf{t = 1} \\
 & & V_t^+ \\
 & \overset{q}{\nearrow} & \\
V_0 = C_0 & & k = e^{r\Delta t} C_0 \\
 & \underset{1-q}{\searrow} & \\
 & & V_t^-
\end{array}
$$

Figure 1: The implicit put option path for the SIFI, where q is the risk neutral propbability the institution will survive 1 year.

the time Δt. The risk neutral probability q is defined by $q = \mathbb{Q}[V_t > e^{r\Delta t}\, V_0]$, which gives

$$q = \mathbb{Q}[L_{\Delta t} \leq VaR_{\beta^*}(L_{\Delta t})] = \beta^* \, ,$$

which is the risk neutral probability of the loss of the company to be bigger or equal to C_0 the VaR_β of the company. The Basel II framework fixes the physical probability, $p = \beta$, of a bank to have its liability below the capital, by asking them to compute the VaR at a threshold of 99%. We thus need to find how does the threshold of 99% in the physical distribution translates in the risk neutral distribution. We assume here that the economic value of the company follows the same process as the share price of the company. If this is the case, the shape of the probability distribution of the economic value of the company is the same as the shape of the probability distribution of its share price. Then, the risk neutral cumulative probability distribution (CDF), $\mathbb{Q}$ can be deduced from the implied volatility of options traded on the market for this particular institution

$$q = \mathbb{Q}[L_{\Delta t} \leq VaR_\beta(L_{\Delta t})] \tag{1}$$

The risk neutral probability q is thus the risk neutral probability of the loss to be lower or equal VaR_β.

We now turn our attention to the payoff X_t of the put option at maturity time t. It is defined by

$$X_t = \min(0, V_t - k)$$

hence, under fair game principle, the price X_0 of the put option is given by

$$
\begin{aligned}
X_0 &= e^{-rt}\mathbb{E}[X_t] = p \times 0 + (1-p) \times (V_t^- - k) \\
&= (1-p) \times (ES_{\beta^*}(L_{\Delta t}) - VaR_{\beta^*}(L_{\Delta t})) \\
&= (1-\beta^*) \times (ES_{\beta^*}(L_{\Delta t}) - VaR_{\beta^*}(L_{\Delta t}))
\end{aligned}
$$

We see here that the price of the put option is proportional to the difference between TVaR and VaR calculated at the same threshold β^*.

From previous empirical studies, we know that financial returns are fat tailed with a tail index $2 \leq \alpha \leq 4$ (see [6, 7]). We also know that the return exceedances have a tail that follows a Pareto distribution, which means that, for β sufficiently close to 1, we have:

$$\lim_{\beta \to 1} ES_\beta(L_{\Delta t}) = \frac{\alpha}{\alpha - 1} VaR_\beta(L_{\Delta t}) \, ,$$

which provides the price of the put option as a function of the VaR and the tail index in the limit of β tending to 1, which is the case with the thresholds used in solvency regulations:

$$X_0 = \frac{1-\beta^*}{\alpha-1} VaR_{\beta^*}(L_{\Delta t}) = e^{r\Delta t}\,\frac{1-\beta^*}{\alpha-1} C_0 \tag{2}$$

If we now assume that we neglect the fact that β^* has to be evaluated from the risk neutral distribution and we take the physical distribution value $\beta = 99\%$ and choose an $\alpha = 3.5$ quite typical value for tail indices of financial returns (see [6] and [7]), and $r = 0\%$, which is more or less the current yield of the government bond with maturity of 1 year, we obtain $X_0 = 0.4\% \times C_0$. It is the price the State should demand yearly to guarantee the SIFI's. The question could still be what about the tail index, but we know that financial returns have all tail indices around this value and that, according to Feller's theorem [2], the tail index is constant under aggregation. Thus the portfolio of assets of the bank should have sensibly the same tail index as those of financial returns (see [6] and [7]), which means a value of the option around 0.5% of the bank's VaR.

This result shows that the value of the implicit put option is proportional to the risk based capital of the company at time t_0, which means that, not making the institution pay for it, would give management an incentive to increase its value by taking more risk on their balance sheet. However, through the bank internal risk model, an increased risk appetite would be transferred back to the option price and if the institution has to pay it, this would make the cost of increasing risk higher for the company. A CEO who would want to take on more risk because he feels safer as a SIFI with his implicit option would be punished by an increased premium. This feedback loop is thus able to avoid moral hazard, of course, under the condition that the risk model is adequate. This is the task of regulators to make sure that banks' internal models truly reflect their risk.

3 Conclusion

Even though it is not clearly stated by the regulators, the SIFI designation implies that the State provides an implicit bailout option to the financial institution. In this paper, we have valued this implicit put option from purely the risk management view. It is a "first principle" valuation with the use of Extreme Value Theory (EVT) and the information available in the market. Its value is proportional to the capital required for the risk of the company. Not asking her to pay it, would give her management the wrong incentives as they will want to increase the value of this option and thus take on more risk. We thus propose to systematically compute the value of this option for each SIFI and ask them to pay it in a fund that would constitute an insurance against the systemic risk. This solution is preferred to those propositions of increasing their required capital as it will bring this money outside the institution and will be managed independently, which is a better guarantee of diversification rather than leaving this responsibility to the same management that could bring the company to bankruptcy by their own policy.

References

[1] F. Corsi, S. Marmi, F. Lillo (2016), *When Micro Prudence Increases Macro Risk: The Destabilizing Effects of Financial Innovation, Leverage, and Diversification*, Operations Research, Article in Advances. *Available on:* `http://dx.doi.org/10.1287/opre.2015.1464`.

[2] W. Feller, 1971, *An Introduction to Probability Theory and Its Applications*, Wiley Series in Probability and Mathematical Statistics, Vol. **2**, 2nd ed., John Wiley & Sons, New York.

[3] Financial Stability Board (2009), *Guidance to Assess the Systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations*, Report to G20 Finance Ministers and Governors. *Available on:* `https://www.imf.org/external/np/g20/pdf/100109a.pdf`.

[4] Financial Stability Board (2014), *How big is the implicit subsidy for banks considered too important to fail*, Global Financial Stability Report 2014, **chap. 3**, 101-132.

[5] R. C. Merton, M. Billio, M. Getmansky, D. Gray, A. W. Lo, L. Pelizzon (2013), *On a new approach for analyzing and managing macrofinancial risks*, Financial Analysts Journal, vol. **69**(2), 22-33.

[6] U. A. Müller, M. M. Dacorogna and O. V. Pictet, 1998, *Heavy tails in high-frequency financial data*, published in the book "A practical guide to heavy tails: Statistical Techniques for Analysing Heavy Tailed Distributions", edited by Murad Taqqu and published by Birkhauser,.

[7] U. A. Müller, M. M. Dacorogna, O. V. Pictet, C. G. de Vries, 2001, *The Distribution of Extremal Foreign Exchange Rate Returns in Extremely Large Data Sets*, Extremes, vol. **4**, 105-127.

[8] D. Richard and B. Tracey (2014), *Too Big to Be Efficient? The Impact of Implicit Subsidies on Estimates of Scale Economies for Banks*, Journal of Money, Credit and Banking, **46**, 219-253.