Economic capital has the potential to make financial services firms more risk-aware in their capital management, enabling investors and regulators to easily compare financial strength and profitability across business lines and sectors. By Vaishnavi Srinivasan and Pradip Tapadar

A unifying approach

Financial services firms are in the business of accepting risk. To be able to fulfil this role, they must understand the risks involved and put in place adequate measures to mitigate them. Traditionally, the amount of capital has been prescriptive in nature and set out by the regulators. With the advent of modern risk management techniques, regulators are moving towards a risk-based capital approach, with different regulations for banks (Basel II) and insurance firms (Solvency II).

However, to ensure all financial firms are treated equally, a risk-based capital calculation technique that works across the board for all financial services firms would be preferable. Capital calculated based on this approach is widely referred to as economic capital.

Economic capital can be used as a concept and a practical tool that unifies the requirements of various parties across the financial services sector, including regulators, customers, managers, capital providers and rating agencies. Firms can also use it as a capital management tool.

In this article, we will define economic capital in a generic way, so that it applies to any firm in the financial services industry. We will then use illustrative examples to show how economic capital can be calculated for companies offering different financial products with varying risk profiles. This will demonstrate economic capital as a tool not only meets the needs of all interested parties, but also unifies capital calculation techniques across all financial services firms, irrespective of their line of operation.

We will use the formal definition of economic capital given by Porteous & Tapadar (2005) for the purposes of this article: “Economic capital, for the business of a firm, is the amount of capital (or excess assets) that this business requires to ensure that its realistic (or market value) balance sheet remains solvent over a specified time horizon, with a prescribed probability or confidence level, following events that are unexpected, yet not so unlikely that they might never occur in practice.”

A company will usually decide how it will raise the capital to back this requirement. For simplicity, we will assume economic capital is always backed by equity capital and invested in cash.

Modelling

Traditionally, companies have used deterministic models to calculate the level of regulatory capital. This entails individually stressing a particular aspect of risk and analysing its effect on the balance sheet. For example, a firm selling annuities could test the effect of interest rates falling by 1%. But this does not tell the firm anything about the likelihood of such an event and therefore is not a probability statement.

This problem is compounded when there are multiple dependent risks. For instance, the same annuity firm can also estimate the effect of a 1% increase in expense inflation. However, these two stresses are not unrelated – that is, the capital that needs to be held under these two stresses is not additive. So, we need a model that will enable us to study and quantify the impact of risk on the balance sheet in a coherent way.

One way to achieve this is to use stochastic models. In this approach, all or most of the key variables affecting a company’s business are modelled stochastically. This entails not only setting the distribution for each of the variables involved, along with the relevant parameters, but also modelling the inter-dependencies of these variables.

Here, we use the stochastic model developed by Porteous and Tapadar (2005). This consists of 21 economic and two demographic variables. Each individual economic variable is modelled as an auto-regressive time series, where the parameters are estimated using historical data, taking future economic outlook into account. A pragmatic approach is key to developing a stochastic time-series model, as parameter estimates based only on historical data may not be completely relevant in the current economic environment or appropriate for projecting future economic scenarios.

As far as demographic variables are concerned, mortality risk has been studied in detail by actuaries for many years. Willets et al (2004) and Willets (2004) offer detailed discussions on current mortality trends, highlighting the fact that mortality improvements in the UK have been affected by different factors, including age, sex and cohorts based on calendar year of birth. We take all these factors into account when estimating future improvements in mortality for each risk group.

We model mortality stochastically, by starting from a base mortality table representing current UK demographics. We then use the trends given in the above reports to estimate and forecast expected future improvement factors. We also introduce variability to reflect uncertainty underlying the projections. The mortality simulations are then based on these stochastically generated improvement factors. While modelling persistency, we allow for the fact that it varies by product line and, unlike mortality risk, can also be affected by one or more economic variables.

Once the individual variables are modelled, we need to consider correlations between them. Modelling correlations of all possible combinations is daunting. A graphical model approach can be used to overcome this by reducing the dimensionality of the model. In a graphical model, a large multivariate structure is studied in small groups, generally shown as connected by straight lines. It does not, however, imply that variables not connected directly are uncorrelated, as all variables in the...
model are correlated by the intermediate interdependencies. As we are modelling correlation between small groups of variables at a time, the whole model is correlated, but correlations are modelled in smaller chunks.

It is important to note this model can be applied to calculate economic capital for a large variety of financial services firms, since it is defined based on generic relationship between the key variables, not specific to any particular type of firm. (See Porteous & Tapadar, 2005, for the full parameterisation of the multivariate time series stochastic model.)

However, stochastic models are not without their disadvantages. We have already mentioned the challenges pertaining to the parameterisation of the variable distributions. Moreover, stochastic models are much more complex to understand and difficult to explain to other parties, including senior management and regulators. They also need more computing power and are more challenging to implement. However, for a proper assessment of financial risk, a stochastic model is a key ally on the way to a uniform measure of economic capital.

In this article, we only consider risks that can be mitigated by holding capital, which include financial, demographic (mortality, persistency), credit and operational (external events such as floods) risks. In our view, operational risks related to internal events, such as fraud, cannot be effectively mitigated by holding capital. These risks need to be handled through better management, processes and controls. Similarly, liquidity risk can be mitigated only through proper financial planning.

Before proceeding, a short note on time horizon. We consider the business in force at the start of our calculations and use what is essentially an actuarial approach to calculate economic capital for the period until the entire in-force business goes off the books. We draw on traditional actuarial principles, which always take a long-term view of the risks involved. The advantage of using a long time period for assessing risk is that a potentially critical risk may manifest itself over a longer time horizon.

Once the model is completely specified, we can set out the steps involved in calculating economic capital. The first step is to use the stochastic model to simulate a projection of a future economic scenario. Based on the generated scenario and taking into account the product involved, we can fully specify all future cashflows associated with the business. This step is repeated a large number of times, each time based on a fresh simulation of future projected economic scenario. We can then quantify economic capital as the amount of capital required at any particular time, which will ensure the business remains solvent over the entire time horizon with a specified probability or percentile level.

In the remainder of this article, we will describe three examples of how the economic capital approach can be employed by any firm in the financial services industry. We will only outline the high-level assumptions for each. The detailed assumptions underpinning these examples are given in Porteous & Tapadar (2005).

A capital repayment mortgage example
Consider a bank that has just sold a portfolio of retail capital repayment mortgages with an average loan size of £100,000 and term of 20 years. It is a variable interest mortgage product where the mortgage yield is modelled stochastically and is aligned with all other general economic variables. We assume the expected mortgage yield is 5.75% and the expected cost of funding is 4.85% – hence, the bank’s interest rate margin is 0.90%.

The economic capital at different percentile levels calculated for this portfolio of business (per mortgage sold) is illustrated in figure 1a. The figure also shows the Basel II Pillar I capital requirement for comparison. The main features can be summarised as follows:

- The economic capital requirement increases as the percentile levels go up. This is entirely as expected because a lower risk of insolvency can be achieved by backing business with increased levels of capital. Also note that economic capital falls over time as the portfolio of business runs off the books. Economic capital requirements are higher in the initial time periods at all percentile levels, which shows the impact of high initial expenses not being recouped from future profit streams. This is exacerbated by poor persistency rates typically prevalent in the retail mortgage business. This has interesting implications for the bank in terms of product design. For example, it might want to analyse and restructure levels of sales expenses incurred for various channels in an effort to bring down the level of economic capital in those initial periods.
- The mismatch between Pillar I regulatory capital and economic capital is striking. Except for the first few months, regulatory capital is much lower than even the 95th percentile economic capital level. This indicates that if the bank is running solely on Pillar I capital, there is more than a 5% chance it will need a fresh capital injection over the time horizon considered. While running the business with lower capital may be tempting, this must be balanced against the risk that the bank may be forced to raise additional capital in times of financial stress – in other words, it may struggle to raise capital just when it needs it most. To cover such eventualities, regulators may require the bank’s management to raise capital to an adequate economic capital level.

Figure 1b shows the densities of rates of return that shareholders would have earned if the bank’s actual capital backing matched regulatory capital and economic capital at different percentile
levels. The main observation is that lower capital results in higher but volatile returns. Clearly, there is a trade-off between the amount of capital and the volatility of returns for capital providers. Hence the full distribution of returns on economic capital should be taken into account while comparing returns between different economic capital levels and across competing products.

In calculating rates of return, we have made a strong assumption that the bank can raise capital whenever required. This may not always be feasible in practice. This highlights the need for the firm’s management and capital providers to understand the risks of operating on a lower than adequate capital backing, *vis-a-vis* the possibility of earning higher returns.

Of course, firms rarely act in isolation and have to take competitors’ product structure and pricing into account when formulating their own strategy. Not all banks will price their retail mortgage product the same way, and not all banks will have the same cost of funding for their mortgages. For example, a large reputable bank might find it easier to arrange for cheaper funds. It may also have the strength of its brand name to charge a higher mortgage rate than its competitors. For this bank, the economic capital requirement will be lower at all percentile levels and rates of return will be higher.

Management’s task is to balance customers’ need for innovative products and competitive prices against the business need to control and mitigate risks. Economic capital techniques can be used to consider the viability of new and existing products and also to compare competing products sold by different firms.

### A lifetime mortgage example

We will next consider a financial services firm, either a bank or a life insurance company, selling a portfolio of equity release lifetime mortgages to couples, who own high-valued illiquid assets such as property, but have low running incomes. We will assume the firm is selling this product to customers with an average age of 75 years and with an average property worth £250,000. The firm provides a mortgage of 40% of the property value at an interest rate of 7% a year, taken out on a joint-life basis. The loan can be repaid any time. If both borrowers die without having repaid the loan, the firm takes possession of the property, sells it, recoups its loan and repays any balance to the estate.

The firm also provides a no-negative equity guarantee (NNEG) to customers, which ensures customers never have to pay more than the value of the property even if the loan exceeds the house price. The risk inherent in this guarantee is taken on by the financial services companies.

Suppose for this portfolio, the firm’s long-term cost of funding is at a higher expected level of 5.5%, reflecting the greater uncertainty involved, which produces a margin of 1.5% for the firm.

The regulatory capital and economic capital at different percentile levels calculated for this portfolio of business (per lifetime mortgage sold) is given in figure 2a. We observe the following:

- As expected, economic capital for the lifetime mortgage product increases with percentile levels. This product, however, has a longer term, as is evident from the long run-off period. The duration of the product is a key factor here – the longer the duration of a product, the greater the chance that risk events associated with the business will materialise. To counter this risk, firms have responded by designing products where higher loans (as a proportion of the property value) are granted only to older customers.
- The slow release of capital over a longer duration for the lifetime mortgage product is also a key feature, again highlighting the long-term nature of the product. The implication for the firm is that capital will be tied up for a considerably longer duration as compared to the retail mortgage product.
- In contrast to the retail mortgage graphs where economic capital peaked at time zero, economic capital curves for lifetime mortgages peak at around 20 years and then fall as the business runs off the books, as customers leave the cohort through loan repayment or death. As the rate of interest is set at a much higher level compared with long-term expected house price inflation, it is around 20 years and beyond when the NNEG bites. For shorter durations, the accumulated loan will generally be lower than the value of the customers’ property, which explains the lower level of economic capital at these durations.

Regulatory capital, calculated assuming a non-bank finance company, has a completely different shape altogether. It peaks at a much earlier duration, at which point it is more than five times the economic capital required at the 99.5th percentile level and falls to less than a fifth of the 99.5th percentile level when economic capital levels are at their peak. This shows that, if run on a regulatory capital basis, the firm will have insufficient capital when it needs it most and excessive capital when the risks are significantly lower.

The rates of return densities given in figure 2b show that at this level of pricing, the product is highly profitable when run on an economic capital basis. However, as the regulatory capital has considerable mismatch with the risk profile of the product and requires an excessive initial capital injection, the rates of return earned are substantially lower. This has important implications for perceived profitability, as capital providers may not get a true picture of the attractiveness of the product when using regulatory capital.

Leaving regulatory capital issues aside, the pricing and cost of funding will of course be different for different firms. This will be reflected in economic capital levels and their rates of returns. So, economic capital can be used to consistently compare lifetime mortgage products across different providers.

Moreover, the concept of economic capital outlined above is generic and purely based on risks inherent in any financial services product. This technique can be applied across different product types, and it provides a common framework to compare different lines of business on a
consistent basis. Comparing the retail and lifetime mortgage examples, we can see that, on average, the lifetime mortgage is more profitable. Also, the distributions of returns on the 99th and 99.5th economic capital levels show there is very little chance the retail mortgage will outperform the lifetime mortgage product. However, at the 95th percentile level, there is a considerable chance of the returns on the lifetime mortgage being either higher or lower compared with the lifetime mortgage.

An annuity example
Finally, we will quantify the economic capital requirements for a life insurance firm selling a portfolio of annuities. We will assume annuities are taken on a joint-life basis by customers aged 65, paying a single premium of £250,000. In return, a level annuity of £1,400 a month is paid until the death of the last survivor. We assume the life insurance firm invests the full premium in long-term UK corporate bonds.

The economic capital at different percentile levels calculated for this portfolio of business (per annuity sold) is given in figure 3a. As before, we observe the following:

- Annuities are much more capital-intensive than the mortgage examples. In fact, from the graphs we see that at the 99.5th percentile economic capital level, a firm with a single annuity contract could have sold more than 10 retail or 100 lifetime mortgage policies with the same amount of capital backing. This reflects the higher risk involved in running annuity business.

The amount of assets under management and the long-term nature of annuities increase their risk profile. Risk is also enhanced by the uncertainty involved in estimating future mortality improvements and the guarantees involved in fixed annuity payments. The investment strategy of an annuity firm also has a huge bearing on its economic capital. Although we have assumed 100% corporate bond investment in our example, a diversified investment strategy involving equities might help reduce economic capital and enhance returns on the capital employed.

- The regulatory capital requirement for annuities peaks much earlier than the economic capital graphs (although not as pronounced as for the lifetime mortgage example) before falling to a much lower level at later durations. This reiterates the mismatch between economic capital and ad hoc rules-based regulatory capital we have seen in the previous two examples.

The densities of rates of return are shown in figure 3b. Comparing the retail mortgage and annuity examples, the average return for retail mortgages is higher than the annuity at all percentile levels. However, while there is little chance that the annuities will earn less than 5%, there is a high probability of negative returns for retail mortgages. Given this information, capital providers might prefer annuities over retail mortgages.

On the other hand, the lifetime mortgage product always produces superior returns compared with annuities. So, the choice between these products is straightforward. Of course, if competition forces the average profitability of lifetime mortgages down to the annuity level, then the choice becomes more complicated as the volatility of returns for lifetime mortgage is higher than that of annuities. All this goes to show that firms have to analyse the full distribution of returns and invest in products taking into account their risk appetite and required profitability.

Conclusion
What does all this mean to the different interested parties?
Anybody can compare the actual capital holding of any firm in the financial services sector with economic capital at specific percentile levels, therefore getting a good idea of the financial health of these firms. This will be of particular interest to regulators concerned about the security of customers and the efficiency of the financial services market as a whole.

Customers can also weigh up the advantages of competitive prices against the risk of a firm going insolvent, credit rating agencies will find rating firms according to their financial strength much easier, and shareholders will be able to decide whether to invest in a risky venture where the prospect of returns is greater but there is a higher chance of default. The underlying principle remains the same — that all interested parties can compare financial firms on a consistent basis, even if they are in different lines of business with different risk profiles. In short, economic capital has the enormous potential of unifying the whole financial services industry and bringing the entire sector under an overarching umbrella.

Pradip Tapadar and Vaishnavi Srinivasan are lecturers at the University of Kent. Email: P.Tapadar@kent.ac.uk, V.Srinivasan@kent.ac.uk

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