# Papers

# Bank capital allocation and performance management under multiple capital constraints

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**Pieter Klaassen**
is Managing Director in risk methodology at UBS AG.

E-mail: pklaassen@alum.mit.edu; E-mail: pieter.klaassen@hispeed.ch

**Idzard van Eeghen**
performs interim and supervisory roles in the financial industry and was until December 2017 CEO/CRO of the Royal Bank of Scotland NV.

**Abstract** To measure performance of individual businesses and maximise shareholder value for the firm as a whole, banks need to decide how much capital to allocate to each business and what cost of capital to charge. Capital is typically allocated to reflect differences in risks and/or regulatory capital requirements. The cost of capital has typically been set more judgmentally and often is not differentiated across business lines. This paper outlines why the authors believe the focus needs to shift to the determination of the appropriate cost of capital. If the cost of capital accounts for differences in risk across business lines, the amount of allocated capital can be chosen more freely and naturally as a function of all competing regulatory and internal capital requirements. This paper describes how differentiation in the cost of capital can be achieved in a practical manner, and how a lack of differentiation leads to flawed pricing incentives and wrong conclusions about the contribution to shareholder value of individual business lines.

**Keywords:** *capital allocation, performance management, shareholder value, cost of capital, capital constraints, economic capital*

## INTRODUCTION

Many banks are active in several markets offering various products. Hence, one of the key decisions to optimise shareholder value is the allocation of capital to each business line. Intuitively, one would allocate most capital to a business line that performs best, thus allowing that business line to expand relative to other business lines. Hence, performance measurement, capital allocation and shareholder value are inextricably linked.

Banks tend to allocate capital to the business line with the highest return on equity (RoE) in order to maximise their overall RoE. This implies that they consider the cost of capital, that is, the minimum return on equity that is required to increase shareholder value (also referred to as the hurdle rate), to be the same for each business line. The risk profile of different business lines, however, is likely to differ; as a result their cost of capital will differ because shareholders require a higher compensation for riskier

investments. By adjusting the leverage (assets divided by equity) at which individual business lines operate, it is possible to equalise their cost of capital again. The leverage must be inverse to the risk profile, that is, the higher the risk the larger the amount of equity per unit of assets, and thereby the lower the leverage. The introduction of risk-based capital requirements, also known as Basel 2, directed banks to allocate capital in a risk-based manner. While not perfect, this made it defendable to assume that the cost of capital was the same across business lines.

Recent changes in capital regulations, and in particular the introduction of a simple leverage ratio, require banks to hold capital based on risk-insensitive measures. Allocating capital to business lines based on the same (risk-insensitive) measures ensures that there is consistency between the allocated amounts of capital per business line and the total required amount of capital. Nevertheless, it cannot be assumed anymore that the cost of capital will be equal between business lines. If banks continue to apply the same performance measures as before, they are at risk of drawing the wrong conclusions when assessing if and by how much each business line contributes to shareholder value. Moreover, in periods when capital regulations change, the required capital to be held per business line will change, creating challenges for consistent performance measurement and management over time. The resulting question is how performance measurement and capital management must adapt to these changes in capital regulations in order to optimise shareholder value. How should banks allocate capital across business lines, and how should they set the cost of capital for each business line? We provide answers to these questions in this paper.

'Literature review' discusses relevant literature. 'Framework of analysis' introduces the basic concepts of our framework. The capital asset pricing model (CAPM) is used to calculate the cost of capital. Shareholder value added is introduced as key risk-adjusted performance measure. It is shown under what assumptions risk-based capital allocation justifies the use of a uniform cost of capital across business lines. 'Capital allocation and performance measurement' discusses the consequences of risk insensitive capital regulations and allocations such as the simple leverage ratio. It is shown that the continued use of the same cost of capital for each business line is likely to lead to materially flawed outcomes. We propose a practical approach for capital allocation and performance measurement that provides proper incentives for product pricing and supports the creation of shareholder value. 'Practical considerations' discusses practical considerations regarding the treatment of tax and the estimation of the cost of capital. The final section concludes with some practical consequences of our recommendations.

## LITERATURE REVIEW

Literature on how banks allocate capital within their firm and what cost of capital they apply for performance management is relatively scarce. Zaik *et al.*[1] describe the performance evaluation system of Bank of America using a RAROC-based approach with a uniform cost of capital for all businesses. RAROC stands for risk-adjusted return on capital. The risk-adjusted return is calculated by subtracting the expected losses from the (expected) earnings for an investment or business line. This risk-adjusted return is divided by an internally allocated amount of capital to that investment or business line to obtain the RAROC. In this system the higher capital allocated to riskier businesses, based on their contribution to the bank's overall earnings volatility, is intended to compensate for the higher risk of these businesses and thus serves to justify that the same cost of capital applies to all businesses.

Kimball[2] describes performance measurement by (US) banks which allocate capital to loans and business lines on the basis of their relative riskiness. He also observes the use of a uniform cost of capital. Later descriptions of bank practices confirm that (the majority of) banks use a uniform cost of capital to evaluate the performance of their business.[3,4] Nevertheless, public information remains scarce, as Ita[5] documents after reviewing the annual reports of the largest 30 global systemically important banks (G-SIB) banks. Only seven banks describe how they allocate capital to their business lines on the basis of their consumption of required regulatory capital and/or economic capital, which is based on the bank's internal quantification of risks, with the majority using regulatory capital. No bank provided information about their cost of capital for individual businesses.

Nevertheless, it is the authors' impression based on anecdotal evidence that most banks use a uniform cost of capital across business lines, irrespective of whether they allocate capital based on required regulatory capital and/or internal economic capital estimates.

The use of a uniform cost of capital is broadly criticised in the literature. Crouhy *et al.*[6] show that if the amount of capital that is allocated to a business line ensures the same probability of default for each business line, as the capital allocation method underlying RAROC assumes, then this is inconsistent with a uniform cost of capital for business lines with different earnings volatilities and correlations with the market. The use of a uniform cost of capital in investment evaluation may result in projects with high volatility and/or correlation with the market being selected that actually destroy shareholder value. To resolve the bias, Crouhy *et al.*[6] propose the use of an Adjusted RAROC which controls for differences in the equity beta of business lines. Carlin *et al.*[7] show that the cost of capital for a bank as a whole will vary with the volatility of its assets even if the amount of equity it holds is adjusted to ensure the same probability of default on its debt. Milne and Onorato[8] illustrate the same point by comparing the cost of capital for debt portfolios of different credit ratings. Using the Vasicek debt portfolio model, they determine the capital needed for each debt portfolio by imposing a common maximum probability of a capital shortfall. The cost of capital as determined using the CAPM model varies considerably across the portfolios, driven on the one hand by differences in return volatility and correlation with the overall market between the portfolios, and on the other hand by differences in the shape (in particular, the skewness) of the return distribution between the portfolios that determine the amount of required risk capital. Ita[5] also highlights that a single cost of capital for different business lines is likely to be inappropriate because the cost of capital for a business line depends on its systematic risk, whereas capital allocation is typically based on measures of systematic and non-systematic risk.

An alternative approach is presented by Stoughton and Zechner.[9] They study the capital allocation problem of a firm with asymmetric information between the central unit and business line manager. They conclude that when investment opportunities are independent across business lines, the cost of capital tends toward the common cost of equity of the institution. Hence, the cost of capital in a diversified financial institution is more nearly equal than suggested in perfect market settings.

Still another approach is followed by Erel *et al.*,[10] building on earlier work from Merton and Perold,[11] Myers and Read[12] and Perold.[13] They derive the optimal capital allocation to individual business lines by imposing that each business line's marginal contribution to the value of the shareholder's option to default on the firm's liabilities (the 'default put') is the same. This results in a higher allocation of capital to business lines that are expected to contribute more to the firm's losses that would lead to default, with default being defined as the moment at which the value of its assets falls below the value of its liabilities. Judging the attractiveness of a new investment in a business line starts from the net present value (NPV) of the investment's expected future cash flows, discounted at a rate reflecting the market risks of the cash flows. This NPV is independent of the firm's existing activities and capital structure; however, they derive an adjusted present value (APV) in which a cost of equity is deducted from the NPV, as well as the investment's contribution to the firm's overall cost of financial distress that is related to the firm's overall amount of equity. This cost of equity does not represent a hurdle rate, but captures for example the tax disadvantage of equity instead of debt financing. A hurdle rate could be derived from the APV, and would be a function of both the market risks of the investment as well as firm-specific risks.

Matten[14] describes various options for dealing with situations in which regulatory capital requirements and internal economic capital estimates strongly differ from each other. One is to allocate the maximum of internal and regulatory capital per business line, but he does not discuss implications for the setting of the cost of capital. Matten does not recommend this approach because the sum of the capital allocated to all business lines will likely be higher than the firm needs in total. A second option is to charge for the use of regulatory capital in the calculation of RAROC as an expense, while continuing to use economic capital in the denominator; however, it is not intuitive how to

choose the cost of regulatory capital. As a third (in his view, preferred) option, Matten suggests allocating capital based on regulatory capital first, and subsequently optimising return on economic capital at a firm-wide level by iteratively adjusting the allocation between business lines.

Our approach differs from earlier literature in that it does not assume or prescribe complex risk-based methods to allocate capital to business lines, which in practice do not seem to be implemented, probably because these methods are very complex. In contrast, we assume that capital allocation not only takes into account the risk profile of the business line, but also external (regulatory) rules. Subsequently, we analyse how performance evaluations must be done, and specifically how hurdle rates should be set, to provide incentives that are in line with the optimisation of shareholder value. Our proposed approach is similar to the first approach suggested by Matten, but adjusts for the potential over-allocation of capital by differentiating the cost of capital across businesses.

## FRAMEWORK OF ANALYSIS

### Cost of equity

The cost of capital is commonly determined using the capital asset pricing model (CAPM).[15–17] The CAPM leads to the following formula for the required return $\hat{r}^E$ on an equity investment:

$$\hat{r}^E = r_f + \beta^E(\overline{r}_M - r_f) \quad (1)$$

$$\beta^E = \rho_{ME}(\sigma^E/\sigma_M) \quad (2)$$

with $\hat{r}^E$ = equilibrium rate of return on the equity investment = cost of capital; $\overline{r}_M$ = expected market return; $r_f$ = risk-free rate of return; $\rho_{ME}$ = correlation between $r^E$ and $r_M$; and $\sigma^E$, $\sigma_M$ = standard deviation of $r^E$ and $r_M$ respectively.

The difference between the expected market return and the risk-free rate is called the market risk premium, that is, the additional return on top of the risk-free interest rate that is required for an investment in a portfolio that mimics the overall market.

When used to derive the required cost of capital for a business line, the CAPM formula indicates that this required return increases with the standard deviation of its return on allocated capital relative to the market return volatility (ie, the more volatile its returns are) and with the correlation of its returns with the market (ie, the less the volatility of its returns can be diversified away).

There is a direct relation between $\beta^E$, and thus the cost of capital and the firm's leverage, that is the amount of equity ($E$) and debt ($D$) the firm uses to finance its assets ($A$). $E$, $D$ and $A$ refer to the book (accounting) values of equity, debt and assets, respectively, so that $E + D = A$. First, the standard deviation of the required return on equity is equal to the standard deviation of the return on assets times the leverage employed ($A/E$). Secondly, the correlation of the equity return with the market return ($\rho_{ME}$ in equation (2)) is equal to the correlation of the return on assets with the market return ($\rho_{MA}$). If $r^A$ denotes the return on assets, and $\sigma_A$ the standard deviation of $r^A$, then we can rewrite equation (2):

$$\beta^E = \rho_{MA} \cdot \sigma_A / \sigma_M \cdot A/E = \beta^A \cdot A/E \quad (3)$$

This shows that $\beta^E$ increases proportionally with the leverage ($A/E$) that the firm employs.

Equation (3) ignores the fact that equity investors are not obliged to pay the firm when the book value of equity becomes negative. This lowers the equity return volatility. When viewing equity investors as holding a call option on the assets of the firm with strike price equal to the amount of debt, and if this call option is valued using the Black-Scholes formula, Copeland[18] show that the corresponding expression for $\beta^E$ equals $\beta^E = \beta^A \cdot A/E \cdot \Delta$, with $\Delta$ the delta of the call option. Since this delta is very close to one for banks (ie, the bank's default probability is close to zero) in all practical instances, we will work with the approximation in equation (3) in the sequel.

When applying equation (3) to our problem at hand, it implies that the required return on capital for a business line needs to be adjusted if the amount of capital that is allocated to it ($E$) changes.

There is a slight twist to equation (3) if we consider taxes, since the return on equity for shareholders is relevant on an after-tax basis, whereas the return on assets is typically considered on a pre-tax basis. The presence of taxes in fact reduces

the volatility of the after-tax return to shareholders, and hence lowers $\beta$. If the impact of taxes is symmetric (ie, taxes reduce profits but create a tax asset in case of losses) and we denote the tax rate by $\tau$, then we can write

$$\sigma^E = (1\text{-}\tau)\ \sigma_A \cdot A/E \tag{4}$$

and equation (3) becomes

$$\begin{aligned}\beta^E &= \rho_{MA} \cdot (1\text{-}\tau)\ \sigma_A\ /\ \sigma_M \cdot A/E \\ &= (1\text{-}\tau) \cdot \beta^A \cdot A/E\end{aligned} \tag{5}$$

in which we consider $\beta^A$ as a pre-tax quantity and $\beta^E$ is a post-tax quantity.

## Shareholder value added (SVA)

To measure the risk-adjusted performance of a firm, we will use the shareholder value added (SVA) metric, defined as

$$SVA = \overline{P} - \hat{r}^E E \tag{6}$$

where $\overline{P}$ is the expected after-tax profit of the firm, $E$ the amount of equity in the capital structure and $\hat{r}^E$ its overall cost of capital. If $SVA > 0$, the profit of the firm exceeds the profit that is needed to compensate its equity holders for the risk, and theoretically its market value of equity should be higher than the book value.

We can also apply the SVA metric to individual business lines. Let $E_i$ denote the amount of capital allocated to business line $i$, $\overline{P}_i$ the expected after-tax profit of business line $i$ and $\hat{r}_i^E$ the required return on capital (hurdle rate) for business line $i$. Then the expected shareholder value added $SVA_i$ equals:

$$SVA_i = \overline{P}_i - \hat{r}_i^E \cdot E_i \tag{7}$$

We can write $\overline{P}_i$ as:

$$\overline{P}_i = (1-\tau)(\overline{m}_i \cdot A_i - r_D \cdot D_i) \tag{8}$$

with $\tau$ = tax rate; $A_i$ = assets in business line $i$; $\overline{m}_i$ = expected gross return on assets in business line $i$, before cost of debt but after accounting for operating costs; $D_i$ = amount of debt in business line $i = A_i - E_i$; and $r_D$ = debt interest rate.

Assuming that the required return on capital is determined according to the CAPM model as described in the previous section, 'Cost of equity', we can rewrite $SVA_i$ as

$$\begin{aligned}SVA_i = (1-\tau)(\overline{m}_i - r_D - \beta_i^A(\overline{r}_M - r_f))A_i \\ +((1-\tau)r_D - r_f)E_i\end{aligned} \tag{9}$$

This can be further re-written as

$$\begin{aligned}SVA_i = (1-\tau)[(\overline{m}_i - r_f - \beta_i^A(\overline{r}_M - r_f))A_i \\ -(r_D - r_f)D_i] - \tau r_f E_i\end{aligned} \tag{10}$$

We can distinguish three components in this expression:

- The first term $(1-\tau)(\overline{m}_i - r_f - \beta_i^A(\overline{r}_M - r_f))A_i$ measures the extent to which the expected gross return earned on the assets exceeds the required return on assets according to the CAPM if the assets were fully financed by equity.
- The second term $-(1-\tau)(r_D - r_f)D_i$ is a correction in case part of the assets are financed by debt *and* the cost of debt exceeds the risk-free rate.
- The third term $-\tau r_f E_i$ is a correction to reflect that taxes reduce the after-tax expected return to shareholders more than they reduce the required return. Taxes reduce not only the after-tax return proportionally, but also the volatility of the (after-tax) return to shareholders, and thereby $\beta^E$. Nevertheless, the required return for shareholders decreases less than proportionally because of the fixed term $r_f$ in the expression for the required return (see equation (1)). This also explains why the risk-free rate $r_f$ features in this term: if $r_f = 0$, the term vanishes.

Equation (10) shows that SVA is independent of the amount of capital allocated to a business as long as all of the following are satisfied:

- There are no taxes ($\tau = 0$).
- The cost of debt equals the risk-free interest rate ($r_D = r_f$).
- The cost of capital charged on the amount of capital that is allocated to a business line is adjusted according to equations (1) and (5).

This highlights the perfect offset between the amount of allocated capital and the cost of capital in a CAPM world without taxes and credit spreads.

In the presence of taxes and/or when the cost of debt exceeds the risk-free rate, then the return earned on the assets needs to increase to generate the required after-tax return for shareholders. The size of the required increase does depend on the amount of capital that is allocated.

To determine by how much, we derive the expression for the equilibrium expected gross return that yields $SVA_i = 0$:

$$\overline{m}_i = r_f + \beta_i^A (r_M - r_f) + (r_D - r_f)(D_i/A_i) + \frac{\tau}{1-\tau} r_f (E_i/A_i) \quad (11)$$

In this expression, we can see the same three components as in the expression for SVA in equation (10):

- $r_f + \beta_i^A (r_M - r_f)$: This is the required return on assets according to the CAPM model in the absence of taxes and when all assets are financed with equity.
- $(r_D - r_f)(D_i/A_i)$: This represents a required add-on for funding the assets partly with debt in case the cost of debt $r_D$ exceeds the risk-free interest rate $r_f$.
- $\tau / (1-\tau) r_f (E_i / A_i)$: This represents an add-on for net tax costs, to reflect that taxes reduce the return to shareholders more than they reduce the required return as explained earlier.

The next tables illustrate by how much the margin on assets needs to increase to avoid a negative impact on SVA from the second and third term. We have assumed the following values for the relevant variables:

$r_f$ = 4 per cent
$\overline{r}_M$ = 10 per cent
$\sigma_M$ = 8 per cent
$\sigma_A$ = 1 per cent
$\rho_{MA}$ = 0.8
$\beta^A$ = 0.1

In the absence of taxes and when the cost of debt equals the risk-free rate, the asset return that yields SVA = 0 equals 4.6 per cent. When the assets are financed by 5 per cent equity ($E/A$ = 5 per cent), Table 1 shows that the required increase in margin to keep SVA = 0 is more sensitive to an increase in the cost of debt above the risk-free rate, and less sensitive to the presence of taxes.

**Table 1:** Required increase in margin on assets as a result of the presence of taxes (rows) and cost of debt exceeding the risk-free rate (columns) when equity equals 5 per cent of assets ($E/A$ = 5 per cent)

| ***E/A* = 5%** | | $r_D - r_f$ = | | |
|---|---|---|---|---|
| | | **0%** | **0.5%** | **1%** |
| Tax rate $\tau$ = | 0% | 0.00% | 0.48% | 0.95% |
| | 15% | 0.04% | 0.51% | 0.99% |
| | 30% | 0.09% | 0.56% | 1.04% |

**Table 2:** Required increase in margin on assets as a result of the presence of taxes (rows) and cost of debt exceeding the risk-free rate (columns) when equity equals 10 per cent of assets ($E/A$ = 10 per cent)

| ***E/A* = 10%** | | $r_D - r_f$ = | | |
|---|---|---|---|---|
| | | **0%** | **0.5%** | **1%** |
| Tax rate $\tau$ = | 0% | 0.00% | 0.45% | 0.90% |
| | 15% | 0.07% | 0.52% | 0.97% |
| | 30% | 0.17% | 0.62% | 1.07% |

This is also the case when assets are financed with more equity and less debt, as illustrated in Table 2 for $E/A$ = 10 per cent. However, the sensitivity of the equilibrium margin to taxes increases whereas the sensitivity to the cost of debt decreases somewhat. This directly follows from equation (11).

This illustrates that taxes and the cost of debt have an impact on SVA, which depends on the actual amount of capital employed. The amount of capital that banks are required to hold has undergone significant change in recent years. In the next section, we explore what the implications of this are for capital allocation and risk-adjusted performance measurement.

## CAPITAL ALLOCATION AND PERFORMANCE MEASUREMENT

If equity is allocated to each business line proportional to the return volatility of the assets, and if the

correlation of the asset return with the market is the same for all business lines, then the cost of capital will be the same for each business line. This is easy to see using equation (5): if $\sigma_{A,1} = k\sigma_{A,2}$, $E_1 = kE_2$, and $\rho_{MA_1} = \rho_{MA_2}$ for two business lines 1 and 2 and a constant $k$, then $\beta_1^E = \beta_2^E$ and, hence, the cost of capital for business lines 1 and 2 is the same.

This has been the traditional approach to capital allocation in financial institutions. The amount of equity that is attributed to a business line was often based on internal economic capital models,[19] or alternatively, on Basel 2 regulatory capital models. The risk sensitivity of these approaches ensured that the amount of equity attributed to a business line would be roughly proportional to its risks. As a consequence, the cost of capital for each business line was set equal to the firm-wide cost of capital. Although measured risks may not always be proportional to asset return volatility and also differences in the correlation of the profit in different businesses with the market would in principle still warrant a differentiation in the cost of capital between business lines, it was not unreasonable to avoid this layer of complexity unless there were clear indications otherwise.

Nevertheless, since the financial crisis in 2008, a number of changes have occurred that have led many banks to change the approach to capital allocation. First, regulatory capital requirements have been increased significantly and nowadays typically exceed the internal economic capital estimates of financial institutions. Consequently, many institutions that used economic capital have started to allocate capital exclusively based on regulatory capital. Secondly, regulatory capital requirements have become less risk sensitive. Risk-weighted assets (RWA) calculations increasingly rely on standardised approaches that are less risk-sensitive than internal models. In addition, many institutions face a capital requirement based on the leverage ratio, which is calculated by taking a flat percentage over eligible assets irrespective of their risks. It is thus by definition insensitive to risks.

With regulatory capital requirements having become more prominent in capital allocation, it can no longer be assumed that the capital allocated to a business is directly proportional to its risks, especially if leverage-ratio based capital requirements are an important determinant of allocated capital. Hence, the common assumption that the cost of capital is the same across business lines does not hold anymore. The question is: how significant is the bias this creates?

If the cost of capital is based on the CAPM, as is often the case in practice, the analysis presented in the section 'Cost of equity' can be used to determine the appropriate cost of equity, assuming that reasonable estimates for the relevant quantities can be made (notably the volatility of profit of each business line, and the correlation of profits with market-wide returns). We will come back to drawbacks of the CAPM in the section 'Alternatives to the CAPM', but will continue to work with the CAPM in the sequel.

## Numerical illustration

In this section, we will assess the significance of the bias that is introduced by not differentiating the cost of capital between businesses when allocation of capital is not proportional to risk. Such a bias will give the wrong picture of risk-adjusted profitability. As a result, businesses that get allocated more capital than their risks warrant without a commensurate lowering of the cost of capital will see their SVAs reduce and will be incentivised to increase margins above the level of competitors who avoid this bias. Such businesses may fail to increase margins sufficiently to become SVA-positive, and management may decide to scale down or discontinue these businesses although in actual fact they contribute value to shareholders.

To illustrate we use the same base data as introduced for the numerical example in the section 'Shareholder value added (SVA)'. Using these data, the asset margin that yields SVA = 0 equals 4.6 per cent in the case that there are no taxes and when the cost of debt equals the risk-free rate.

Table 3 shows the required cost of capital for shareholders according to the CAPM as a function of the leverage employed (expressed by the ratio $E/A$) and the tax rate. In line with the analysis presented in the section 'Cost of equity', the cost of capital decreases when less leverage is employed (higher $E/A$) and the higher the tax rate is (since taxes dampen the profit volatility).

Suppose a bank consists of multiple business lines that differ in riskiness (ie, in asset return volatility $\sigma_A$). If the bank assigns the same amount of capital

**Table 3:** Cost of capital for shareholders according to the CAPM as a function of leverage (expressed by the ratio *E/A*) and the tax rate, using the numerical example introduced in the section 'Shareholder value added (SVA)'

| | | ***E/A* =** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **2%** | **3%** | **4%** | **5%** | **6%** | **7%** | **8%** |
| Tax rate $\tau$ = | 0% | 34.0% | 24.0% | 19.0% | 16.0% | 14.0% | 12.6% | 11.5% |
| | 15% | 29.5% | 21.0% | 16.8% | 14.2% | 12.5% | 11.3% | 10.4% |
| | 30% | 25.0% | 18.0% | 14.5% | 12.4% | 11.0% | 10.0% | 9.3% |

Note: The shaded column corresponds to the base parameter values of our illustrative example.

**Table 4:** Cost of capital for shareholders according to the CAPM as a function of the asset return volatility $\sigma_A$ and the tax rate, using the numerical example introduced in the section 'Shareholder value added (SVA)'

| ***E/A* = 5%** | | $\sigma_A$ = | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **0.7%** | **0.8%** | **0.9%** | **1.0%** | **1.1%** | **1.2%** | **1.3%** |
| Tax rate $\tau$ = | 0% | 12.4% | 13.6% | 14.8% | 16.0% | 17.2% | 18.4% | 19.6% |
| | 15% | 11.1% | 12.2% | 13.2% | 14.2% | 15.2% | 16.2% | 17.3% |
| | 30% | 9.9% | 10.7% | 11.6% | 12.4% | 13.2% | 14.1% | 14.9% |

Note: The shaded column corresponds to the base parameter values of our illustrative example.

**Table 5**: Required net margin on assets to achieve SVA = 0 if the cost of capital shown in Table 4 is applied to a business line and the amount of capital allocated equals 5 per cent of its assets, as a function of asset return volatility $\sigma_A$ and the tax rate, using the numerical example introduced in the section 'Shareholder value added (SVA)'

| ***E/A* = 5%** | | $\sigma_A$ = | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **0.7%** | **0.8%** | **0.9%** | **1.0%** | **1.1%** | **1.2%** | **1.3%** |
| Tax rate $\tau$ = | 0% | 0.42% | 0.48% | 0.54% | 0.60% | 0.66% | 0.72% | 0.78% |
| | 15% | 0.46% | 0.52% | 0.58% | 0.64% | 0.70% | 0.76% | 0.82% |
| | 30% | 0.51% | 0.57% | 0.63% | 0.69% | 0.75% | 0.81% | 0.87% |

Note: The shaded column corresponds to the base parameter values of our illustrative example.

to each business line relative to assets (ie, same ratio *E/A* for each business line), for example, based on a firm-wide leverage ratio requirement, and if it does not differentiate the cost of capital between business lines, then the bank will require above-market returns for low-risk business lines and below-market returns for high-risk business lines. In other words, this will provide an incentive to the high-risk business lines to expand, whereas they may actually destroy shareholder value, and make it difficult for low-risk business lines to compete.

This is illustrated in Table 4. Under the assumption that the capital allocated to each business line equals 5 per cent of assets, Table 4 shows what the required cost of capital is as a function of the asset return volatility for a business line and the applicable tax rate. For example, if the tax rate equals 15 per cent and if the bank-wide asset return volatility equals 1 per cent, then the appropriate cost of capital for the firm as a whole would be 14.2 per cent. If a specific business line has an asset return volatility of 0.8 per cent, however, then the required return on the allocated capital for this business line should be 12.2 per cent instead of the 14.2 per cent that is valid for the firm overall.

Using equation (11), we can determine what the required margin is to achieve SVA = 0 corresponding to the cost of capital that is shown in Table 4. The equilibrium net margin (ie, after deducting the cost of debt of 4 per cent) is shown in Table 5.

Suppose now that the cost of capital is not differentiated across business lines, that is, the firm-wide cost of capital of 14.2 per cent (assuming a tax rate of 15 per cent) is imposed on each business line, independent of the asset return volatility of the business line. Then each business line would need to generate a net margin of at least 0.64 per cent to meet the imposed cost of capital of 14.2 per cent. For business lines with an asset return volatility lower than 1 per cent, however, this is above the margin required by the market when capitalised with 5 per cent equity. The opposite holds for business lines with an asset return volatility above 1 per cent. As a consequence, the firm will underprice its risky businesses and overprice its low-risk ones. Competition may not allow overpricing to occur, leaving the bank with underpriced risks.

## Proposed approach to capital allocation

We have shown that not differentiating the cost of capital between businesses when allocation of capital is not proportional to risk will, potentially significantly, distort the evaluation of risk-adjusted profitability and commercial pricing decisions. In this section, we present our proposal how to allocate capital and determine the cost of capital for individual business lines that takes into account the multiple capital constraints faced by most businesses and the insights from the analysis provided up to here.

As shown in the section 'Shareholder value added (SVA)', in the presence of taxes and/or when the cost of debt exceeds the risk-free interest rate, it is desirable for proper risk-adjusted performance evaluation that the amount of capital allocated to a business reflects as closely as possible the actual capital needed to support that business. This capital need must take into account both minimum regulatory capital requirements and an internal view of how much capital is needed (eg, through economic capital or stress testing estimates). Intuitively, it is difficult to justify allocating less capital to a business line than is needed from an internal risk or from an external regulatory perspective. We therefore propose allocating the maximum of all capital requirements to each business line. The cost of capital should then be determined based on the leverage implied by this amount of allocated capital, along the lines described in the section 'Framework of analysis'.

When capital is allocated based on the maximum of stand-alone required regulatory capital and an internal economic capital estimate, then the total amount of capital allocated to all businesses may exceed the total amount of capital that the firm has, because diversification benefits are ignored. Such diversification benefits exist if the sum of stand-alone economic or regulatory capital across business lines is higher than the bank's total economic or regulatory capital, and in case different capital requirements are binding for different business lines. When the performance of a business line is assessed based on its stand-alone capital requirement, thereby ignoring its contribution to diversification effects within the firm as a whole, business lines may argue that they are 'punished' by getting allocated too much capital. This claim is not correct, however, provided that the cost of capital per business line will be based on the actual amount of capital allocated, and hence will be lower if the amount of allocated capital is higher.

There may be other considerations for taking account of diversification benefits such as providing incentives to managers to optimise diversification benefits between business lines or avoid concentration risks on a firm-wide basis. In practice, however, such effects on diversification benefits and concentration risks only have a material impact on measured performance in case of large changes in risk taking (eg, a merger), and are not really significant in the regular course of business. Hence, alternative performance measures may be superior to incentivise managers to properly manage diversification and concentration effects.

In conclusion, we reiterate our proposal that capital is allocated to each business line based on the maximum of their stand-alone internal economic capital estimate or external regulatory capital requirements. Ignoring diversification benefits does not penalise the business line per se, since the cost of capital will be lower if allocated capital is higher.

# PRACTICAL CONSIDERATIONS

In this section, we discuss a number of practical considerations when implementing a capital

allocation and performance measurement scheme as outlined above.

## Performance measurement before or after tax

What counts for shareholders is the after-tax return that the firm generates; however, for internal performance measurement it is more natural to consider pre-tax returns, because taxes are typically not determined by business line, but paid by the individual legal entities that make up the firm. It is therefore usually difficult, if not impossible, to determine the actual tax rate for a business line. If internal performance measurement per business line is based on pre-tax profits, then the internal cost of capital per business line should also be determined as if the business line does not pay taxes. The resulting higher cost of capital offsets the higher pre-tax profits compared to when taxes would be taken into account, and ensures a proper risk-adjusted return evaluation.

## Estimating beta

The CAPM is a stylised model that makes certain abstractions from reality. Firms therefore usually do not estimate beta on a bottom-up basis (ie, estimate $\rho_{ME}$, $\sigma^E$ and $\sigma_M$ individually), but rather derive it from a statistical analysis by regressing the firm's market value returns on the returns of a suitable market index. The beta estimated in this way implicitly incorporates any adjustments that the market makes for the simplifying assumptions embedded in the CAPM. This approach does have its own challenges, however.

First of all, the nature of the activities of a firm, and thus its volatility and correlation with the market, as well as its capital structure, may have changed over time. If such changes are material, they should be taken into account in the regression analysis. Furthermore, estimates obtained from data on the market value of equity may not directly be applied to the book value of equity. For example, if the market value relative to the book value (market-to-book ratio) of a firm is significantly more or less volatile than for the market as a whole, the estimated beta is not directly applicable to the book value of equity and would need to be adjusted to correct for the difference in volatility of market-to-book ratios.

Secondly, Fama and French[20] summarise evidence that the explanatory power of such regressions has been relatively poor, and that additional variables would need to be included in the regression equation to enhance the explanatory power. It is not clear how to reflect these additional variables in the determination of the cost of capital for individual business lines, however.

Thirdly, it is not possible to perform this analysis for individual business lines, since they have no quoted market value. One possibility is to look for other firms of which the nature of activities and risk profile are similar to those of the business line under consideration. If these can be found, it is important to reflect any differences in capital structure in the beta estimates. For example, if stand-alone comparable firms use less leverage than what is implied by the amount of capital that is allocated to a business line, then the beta for the business line should be higher than the one estimated for the comparable firms (see equation (3)).

If no suitable comparable firms exist for a business line, then alternative approximations will be necessary. The beta estimate for the firm as a whole could be used as a starting point and scaled up or down for an individual business line depending on income volatility and leverage employed. Scaling for leverage is relatively straightforward provided balance sheets are produced per business line. Scaling for relative income volatility estimates could be derived from the size of economic capital or stress test contributions per business line, normalised for differences in size between business lines.

There is no simple recipe to come up with suitable beta estimates for individual business lines. Inevitably, it will involve a fair amount of judgment; however, it should be possible to arrive at directionally correct adjustments that make performance reports more accurate than assuming betas are the same for all business lines. Moreover, when differentiation in beta across business lines takes into account differences in the contribution to important internal risk metrics, such as stress testing and economic capital estimates, then this

will provide the businesses proper incentives for the active management of their risks.

## Alternatives to the CAPM

In the CAPM, the required cost of equity is a function only of its stand-alone equity return volatility as well as the correlation of these returns with the overall market. Various papers have illustrated violations of these assumptions. Chatterjee *et al.*[21] have shown that not only the correlation of a firm's returns with the market is important, but that also firm-specific risks have an impact on a firm's required return on equity if the cost of insolvency is material.

Cholette and Lu[22] and Bali *et al.*[23] show in addition that not only the volatility of returns matter to investors, but also tail risks. That is, if two firms have the same volatility of return, but one has larger tail risks than the other, then investors require a higher rate of return for the former. This provides a motivation to consider economic capital and/or stress testing contributions as a means to differentiate beta across business lines, as suggested in the section 'Estimating beta'.

Arzac and Bawa[24] have suggested an alternative to the CAPM which explicitly considers tail risk by assuming that investors aim to maximise the expected return on their investment under the constraint that the probability of a decline in wealth by a certain amount is smaller than a specified value. Parameterisation of this model is even more challenging than for the CAPM, however, and their model has not found acceptance as alternative to the CAPM.

Despite the known shortcomings of the CAPM, no alternative has been suggested in the literature that has gained acceptance as a viable and practical alternative.

# CONCLUSION

Many, if not most, banks assign the same cost of capital to all business lines. This practice may be defendable if capital is allocated proportionally to the underlying risks in the respective business lines, for example, when based on economic capital or advanced measures of Basel 2 regulatory capital. Nevertheless, this assumption is increasingly under pressure with the reduced use of economic capital and the introduction of risk-insensitive regulatory capital measures. We have shown that this can lead to significant biases in cost of capital and commercial pricing decisions.

To address these potential biases in performance measurement and management we propose the following approach:

- Allocate capital to each business line based on the maximum of all competing capital requirements. This is intuitive as businesses should be compliant with both internal risk and external regulatory capital requirements. In doing so, we advocate to calculate capital requirements per business line on a stand-alone basis because this avoids dealing with the complex issue of allocating diversification effects.
- Calculate the cost of capital based on the allocated capital, and thus the actual leverage, of the business line. If more capital is allocated to a business line due to risk-insensitive measures and/or because diversification effects are ignored, then this will be compensated by a lower cost of capital. This avoids distortions in calculated SVA and prevents that businesses are incentivised to set margins that are lower or higher than justified from a risk perspective.

Calculating the cost of capital correctly is not trivial. Measuring the volatility of returns and correlations is fraught with data problems. If there are no suitable data per business line then we may have to start by estimating the cost of capital at the firm level. Subsequently, adjusting the cost of capital per business line for their actual leverage is a first and necessary step. Next, economic capital and stress testing may provide input to adjust the cost of capital for differences in volatility between business lines. In this way it should be possible to make directionally correct adjustments to derive cost of capital estimates per business line.

The CAPM has been criticised for its simplifying assumptions, and its predictive power has been sub-par. An important simplification is that risks are measured by way of the volatility of the firm's

returns and the correlation of these returns with the market; however, in reality investors also care about firm-specific risks as well as extreme downward risks. Research has confirmed that these are relevant factors determining the cost of capital. An existing risk measure that focuses on the risk in the (extreme) tail of the firm's loss distribution is economic capital. Economic capital encompasses both macro- and firm-specific risks. The contribution of each business line to economic capital can be determined as well, and this information could be used to adjust the cost of capital per business line. This can partly overcome some of the limitations of the CAPM, but the question how to accurately estimate the cost of capital of banks and their business lines in practice clearly warrants further research.

## Authors' note

The opinions in this paper are their own and not necessarily of their employers.

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