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BANK CAPITAL: A MYTH RESOLVED

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ABSTRACT

In order to promote financial stability, regulatory authorities pay a lot of attention in setting minimum capital levels. In addition to these requirements, financial institutions calculate their own economic capital reflecting the unexpected losses and true risk according to the specific characteristics of their portfolio. The current Basel I framework pays little or no attention to the creditworthiness of a borrower in deciding on the regulatory capital requirements. As a result, a lot of banks remove low-risk assets from their balance sheets and only retain relatively high risk assets on balance. The recently introduced Basel II framework should result in a further convergence between regulatory and economic capital. However, recent papers (Elizalde et al., 2006; Jackson et al., 2002 and Jacobson et al. 2006) argue that also under Basel II, regulatory and economic capital will have different determinants. This paper first gives an overview of capital adequacy and then further describes the differences and similarities between economic and regulatory capital based on a literature review.

I. INTRODUCTION

Financial institutions play a crucial role in today's globalized economy. Because of their expertise and by monitoring and screening potential borrowers, these financial intermediaries have a comparative advantage in overcoming asymmetric information (Diamond, 1984). As such, one of the fundamental roles of these financial intermediaries is capital allocation by lending funds that have been deposited on their accounts. These deposits are subject to a "first-come-first-serve" rule. In a negative environment with rumours about the bank holding low quality assets, this could eventually lead to a bank run.

Over the past decades, banks have been flooded with new trends like disintermediation, low competitive margins, expansion of off-balance sheet products dominated by derivatives etc. As a result, the risk profile of financial institutions has evolved dramatically. To a broad extent financial institutions are typically confronted with credit, market and operational risk. The default history of financial institutions shows that credit risk is the most important threat to bank solvency. Credit risk can be defined as the risk of a decrease in value or a loss due to an unexpected detorioration in the credit quality of a counterparty. In the light of the recent evolutions, this risk factor has become more complex than ever before, and revolutionary changes are taking place in the management of credit risk.

To protect banks against failure and to prevent an economic crisis due to contagion and systematic risk, debtholders and regulators want banks to maintain a certain level of capital. However, bank management and shareholders have an incentive to minimize capital as this frees up economic resources that can be used for value creating activities and as such increase the return on equity. As a result of these conflicting interests, bank capital needs to be optimized.

In order to further promote financial stability, regulatory authorities pay a lot of attention to setting minimum capital levels. They could address this issue by setting capital requirements that decreases the default probability. However, increasing equity with a certain amount might go along with social costs (Berger, 1995). As such regulators should make a trade-off between the benefits of reducing systematic risk by imposing high capital levels and the associated social cost of declining financial intermediation (Santomero and Watson, 1977).

Besides these regulatory requirements, financial institutions calculate their own economic capital reflecting the unexpected losses and true risk according to the specific characteristics of their portfolio (Jackson et al., 2002).

Eventhough there is an extended literature about capital regulation and Basel II, there is no paper that gives an overall picture about the determinants and challenges of both economic and regulatory capital. Furthermore the existing literature on economic capital is small and the theoretical comparison to regulatory capital is practically unexplored. To our knowledge, only the paper of Elizalde et al. (2006) compares economic to regulatory capital. However in their model they define economic capital as the capital that would be chosen by the shareholders in the absence of capital regulation. In our paper economic capital coexists with regulatory capital and is defined as the capital level that is required to cover unexpected losses with a certain probability. Furthermore, in this paper we focus on the way both capital numbers are calculated rather than on what is driving them from a theoretical point of view.

The paper continues with an overview of capital adequacy and then further describes the differences and similarities between economic and regulatory capital based on a literature review.

II. CAPITAL ADEQUACY – REGULATORY CAPITAL

Financial institutions are able to forecast the average risk and associated credit loss of their assets. These so called expected losses[1] (EL) are part of doing business and should be covered by and reflected in the pricing of assets and through provisioning. However banks might also experience losses that exceed expectations. These so called unexpected losses (UL) should to a certain extent be covered by bank capital.

"At some level the capital is adequate, implying that the deposits are safe enough" (Sharpe, 1978). This quote shows that capital requirements exist to reduce the probability that banks will fail.

[1] The expected loss of a portfolio can be defined as the multiplication of PD, LGD and EAD (cf. infra).

The principal concern of the authorities who set capital requirements is the protection of the economy against systematic risks. Furthermore they are intended to protect government, central banks, depositholders and other stakeholders against the cost of financial distress, agency problems, etc…

By imposing high capital levels, small investors are protected and potential systematic effects of bank failure are countered. However extremely high capital requirements might create efficiency costs (Jackson et al., 2002).

To prevent negative consequences of setting inaccurate capital requirements, regulatory authorities should take into account this trade-off. Possible negative consequences are the diversion of financial resources from their most productive use, artificial incentives to take off-balance sheet risk etc.

We will now further discuss the different components of capital. It should be noted that both the assets and the capital used in regulatory capital ratio are hard to quantify.

2.1 Quantifying book capital

In 1988, the Bank for International Settlements (BIS), introduced the Basel I Accord that set the minimum capital requirement at 8% of risk weighted assets, consisting at least for 50% out of tier 1 capital (cf. infra). Under Basel II this numerator remains unchanged.

In their statement, the BIS stresses that common stocks and retained earnings should be the core elements of capital (BIS, 1998). These funding sources are available to absorb potential losses and are considered the most reliable and liquid. Tier 2 capital, which mainly consists of subordinated debt and general provisions, but also includes undisclosed reserves, revaluation reserves and hybrid instruments, is far less reliable.[2]

Berger et al. (1995) state that in order for an instrument to qualify for regulatory capital, three characteristics should hold: it should be junior to the claims of the deposit insurer, it should be patient money and it should reduce the moral hazard incentives of the bank. In some circumstances equity only meets the first two objectives.

The actual effect of bank equity on portfolio risk is highly contested. Koehn and Santomero (1980), Keeton (1988) and Kim and Santomero (1988) show that a relative increase in equity can have both a positive (increase) and negative (decrease) effect on the bank portfolio risk. However Furlong and Keeley (1989, 1990) only found a negative effect on portfolio risk for value maximizing banks with publicly traded stocks. This was again contested by Gennotte and Pyle (1991) under the assumption of decreased return on investment. Empirical evidence reveals a negative relation between the level of equity and the risk profile of a bank (Lane et al (1986), Avery and Berger (1991b), Cole and Gunther (1995)). However Thomson (1991) argues that the level of equity has no direct effect on bank performance.

Also subordinated debt meets all the criteria identified by Berger et al. (1995); empirical evidence for the third criteria is somewhat weaker.

2.2 Quantifying credit risk weighted assets

The denominator of the capital ratio should reflect the bank's risk exposure. Practice shows that it is not that straightforward to develop a measure of risk exposure that is both accurate and easy to apply across different financial institutions.

2.2.1 Evolution from Basel I to Basel II

Capital regulation should take into account the changes in banking and risk management. Still, the 1988 Basel I framework pays little or no attention to the creditworthiness of a borrower in deciding on the regulatory capital requirements. As such, the denominator of the capital ratio fails to capture the true economic risk. As a result, a lot of banks remove low-risk assets from their balance sheets and only retain relatively high risk assets on balance (Jones, 2000).

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[2] For purpose of completeness we should mention the Basel Committee on Bank Supervision also distinguishes tier 3 capital. As tier 3 capital, mainly constituted from short term subordinated debt, only serves to cover market risk, and as such can not be used as a cushion against credit risk, we will not go into further detail.

By reallocating their asset portfolio, differences between economic and regulatory capital are being arbitraged[3]. Concerns about the possible extent of these arbitrage actions, encouraged the Committee on Banking Supervision to revise the existing framework and in 1999, the first consultative paper on Basel II was published.

The major objective of Basel II is to further align regulatory capital with economic capital demanded by its different counterparties (Gordy and Howells, 2004).

Furthermore, Basel II should "develop a framework that would further strengthen the soundness and stability of the international banking system while maintaining sufficient consistency that capital adequacy regulation will not be a significant source of competitive inequality among internationally active banks" (BCBS, June 2006).

This new framework is based on three reinforcing pillars depicted in the figure below. Pillar 1 defines new risk-based requirements for credit risk and a new charge for operational risk, Pillar 2 sets requirements for supervisory review, and Pillar 3 is related to market discipline and the associated disclosure standards. In this article we will focus on the first pillar and more specifically on the capital requirements for credit risk.

Insert Figure 1 About Here

Within the new framework, there are two approaches to calculate the capital requirements for credit risk: the standardised approach and the internal rating based (IRB) approach.

[3] Regulatory arbitrage refers to the fact that a bank takes advantage from the difference between regulatory and economic capital. If the true risk of a bank asset is higher than the regulatory weight, the bank will have an incentive to keep these assets on balance. However if the true risk is lower, the bank will remove the asset by means of securitisation. As such, the presence of regulatory arbitrage will increase the overall risk of financial institutions.

Under the Standardised Approach, the risk weights depend on an external rating provided by external credit assessment institutions (ECAIs). When no external rating is available, a default value is applied that is a conservative estimate of the average risk for counterparties. Under the standardized approach a limited number of risk mitigations tools such as financial collateral and guarantees are allowed. Because of its simplicity, especially small and medium sized financial institutions are expected to adopt this approach. The standardised approach is conceptually quite similar to the current framework, but it is more risk-sensitive. Where Basel I only makes a distinction in ratings between corporates, sovereigns and interbank facilities, the standardised approach aims at providing a greater sensitivity to credit risk by creating different risk buckets within each category based on external ratings (Van Roy, 2005).

Notwithstanding this evolution, there is still insufficient differentiation among creditors and as the capital requirements for the investment grade facilities remain to be too high and those for the noninvestment grade facilities too low, the incentive for regulatory arbitrage will remain to exist.

The internal rating based (IRB) approach allows for much more differentiation in credit risk and should significantly reduce the incentives to engage in regulatory capital arbitrage. Under this approach capital for credit risk is calculated bottom-up, implying that capital requirements are calculated on the asset level and are added up at the end. Banks are allowed to determine the values for certain risk parameters based on internal models. The following parameters are included:

-***Probability of default (PD):*** probability counterparty is not able to meet its obligations

-***Loss given default (LGD):*** procentual loss in case of default, usually ranges from 0-100% [4]and is measured on a product basis rather than on a counterpart basis

-***Exposure at default (EAD):*** amount at risk at time of default consisting of the amount currently drawn and an estimate of future draw downs available (credit conversion factors)

-***Maturity (M):*** remaining lifetime of the loan, ranges from 0 to 5 years (=cap)

[4] LGD can exceed 100% because of associated costs, but might also fall under 0% because of penalty fees.

An important issue for the strength of the IRB approach is the reliability of the parameters banks provide. As such, banks will only qualify for the IRB approach, if they are able to convince regulators that the models they use are sufficiently sophisticated. We can distinguish between the foundation and the advanced IRB approach. Under the foundation IRB approach, banks are required to use a supervisory value as opposed to an internal estimate for LGD, EAD and M (constant at 2.5 years). Furthermore the advanced IRB approach allows to take more collateral types into account provided that the bank uses sound internal valuation methods.

Because of the required investments and sophistication of the IRB approach, especially large financial institutions are expected to choose this method. By using the internal risk assessments of banks for setting capital requirements, the IRB approach promotes the adoption of stronger risk management practices by the banking industry. The internal systems used for regulatory capital should meet certain criteria and supervisory approval. In this view, the IRB approach can be regarded as a compromise between a purely regulatory measure of credit risk and a fully internal model based approach.

Under the IRB approach financial institutions have to categorize their exposures in at least 5 broad classes of assets with different underlying risk characteristics: corporates, banks, sovereigns, retail and equity. For each of these asset classes there are risk components, risk-weight functions and minimum requirements. The risk components are delivered by the financial institutions themselves. So, the IRB approach is much more risk-sensitive than the Standardized approach. However, as mentioned before, they are subject to the standards defined by the BIS. Furthermore, banks that rely on the foundation approach only estimate PD and for the other parameters they rely on supervisory estimates (BIS, 2004).

The philosophy of the IRB approach is based on the frequency of bank insolvencies supervisors are willing to accept[5]. By means of a stochastic credit portfolio model, capital is set to assure that there is only a very small pre-defined probability for the amount of unexpected loss to exceed the amount of capital. This VAR approach is explained in the figure below.

[5] As mentioned before, in order to prevent moral hazard considerations for banks to take too much risk, it is not advisable to completely eliminate the credit risk.

Insert Figure 2 About Here

Under Basel II, capital is set to maintain a fixed confidence level of 99.9%, implying that the probability of a bank to suffer losses that exceed capital is on average once in a thousand years.

For the model used in Basel II to be widely applicable, it has to be a portfolio invariant model, i.e. the capital required for an exposure only depends on the risk of that exposure and not on the portfolio it is added to. As a result of this model restriction, the risk weight function under Basel II is based on an Asymptotic Single Risk Factor, where all systematic risk that affects borrowers is captured in one single risk measure (Gordy, 2003). The underlying assumption is that the bank's credit portfolio consists of a large number of small exposures. If this holds, the idiosyncratic risk associated with an individual loan is cancelled out and only the systematic risk remains. In the ASRF approach, there is only one systematic risk factor, implying that all loans in the portfolio are subject to the same set of market conditions. As a result, for a large portfolio of loans, the total capital requirement equals the weighted sum of the marginal capitals for individual loans. The model was further specified taking into account Merton's (1973) and Vasicek's (2002) ground work and resulted in the following risk-weight function:

$$K = \left[LGD * N\left[(1-R)^{-0.5} * G(PD) + \left(R/(1-R)\right)^{0.5} * G(0.999)\right] - PD * LGD\right] * \left(1 - 1.5 * b(PD)\right)^{-1} * \left(1 + (M - 2.5) * b(PD)\right)$$

This formula calculates the conditional expected loss based on conditional PDs and downturn LGDs. The average PDs that are provided by banks and reflect normal business conditions are being transformed in conditional PDs reflecting default rates based on a conservative value of the systematic risk factor, through a supervisory mapping function. As there is no such function for LGDs banks are expected to provide LGD reflecting economic-downturn conditions. The conditional expected loss includes both expected and unexpected loss, however as it was decided that capital should only cover unexpected loss (the UL concept), a correction for EL is required. Further, there is also a maturity adjustment taking into account that long-term credits are riskier than short-term credits and that these maturity effects are stronger for obligors with a low default probability.

The degree of the obligor's exposure to the systematic risk component is reflected in the asset correlation (R). Under the IRB approach, the asset correlations should be determined using a formula of the Basel Committee. These formulas are based on the observation that asset correlation increases with size and decreases with increasing PD (Lopez, 2004).

It should be noted that the latter has been contested by several studies (e.g. Dietsch et al., 2004). As retail and SME credit are found to be less prone to systematic risk, these loans will receive another treatment than corporate loans and will require less regulatory capital for a given default probability.

Besides the fact that the above function does not explicitly take into account portfolio and diversification effects, it also ignores the potential correlation between PD and LGD and by doing so it potentially underestimates the capital requirement.

Capital regulation has received a lot of attention over the past decades. However, the paragraphs above show that a risk based capital ratio might not be the ideal tool to mitigate bank risk (see also Berger et al., 1995). The capital in the numerator is difficult to measure and may not always control moral hazard incentives. Also the denominator appears to be difficult to measure and even under Basel II can be considered to be only a weak reflection of risk. Blum (1999) argues that capital adequacy requirements might not reduce risk. Also John et al. (2000) argue that capital regulation might not be the ideal tool to control risk. They show that the effectiveness of capital regulation depends on the available investment opportunities.

Based on these flaws and taking into account the fact that the underlying objective of capital adequacy is to mitigate bank insolvency risk, it might be that regulatory capital is set too high. As a consequence banking cost will increase and financial intermediation will be reduced, which both will have a negative impact on the economy. Multiple capital ratios, a greater reliance on the private sector mechanism, narrow banking etc might be an answer to the identified problems (Avery and Berger (1991), Kane (1995), Miller (1995)).

Also Benston and Kaufman (1996) and Dowd (1999, 2000) have contested the arguments in favour of bank capital regulation. They claim that capital adequacy regulation is both unnecessary and incapable of improving banks' capital position more than the banks could do on their own. In Dowd's view, shareholders can enforce proper risk behavior.

Flannery and Ranjan (2002) show that the observed increase in capital in US banks especially in the second half of 1990s can to a large extent be explained by market discipline. More specifically over the past decades a bank's counterparties have become more aware of their exposure to a bank's default risk.

Furthermore, many financial institutions seem to hold capital in excess of the required amount and therefore the capital requirements imposed by Basel II can not be considered as binding.

The latest Qualitative Impact Study (QIS 5) that measures the expected impact of Basel II on the industry even shows that on average and especially under the advanced IRB approach, the minimum required capital is expected to drop relative to the current accord. In response to this expected drop in regulatory capital, banks in the US will have to maintain a 3% tier 1 leverage ratio[6] as an additional safety measure. Also in Europe there are advocates of this "US leverage ratio" to prevent capital of falling below a level that comprises financial stability.

The reason why banks hold excess capital is to avoid any supervisory intervention or to qualify for certain activities. Another reason why capital is higher is of course the fact that Basel II fails to recognize certain types of risk (e.g. business risk, duration risk[7]). Previous empirical studies (Peltzman (1970), Mingo (1975), Dietrich et al. (1983)), investigating the impact of regulations on equity in the 60s and 70s, also found regulations did not have an impact on capital levels. Mingo (1975) is an exception. Yet, Dietrich et al. (1983) show that Mingo's findings of significant regulatory influence is a proxy for binding deposit rate ceilings, which led banks to increase capital to lure depositors.

Important to keep in mind is that the ultimate goal of financial institutions is to maximize shareholder value taking into account the different restrictions and obligations they are being confronted with, and thus not blind compliance with regulatory measures. Furthermore, the fundamentals underlying capital requirements and risk measurement should be extended to the pricing of bank products. This need for risk adjusted pricing and consequently risk adjusted performance measures is especially important in the search for the creation of shareholder value.

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[6] The leverage ratio equals core capital as a percentage of non-risk weighted assets

[7] Interest rate risk as a result of a mismatch between fixed rate and variable rate assets and liabilities (Palia et al. (2003)).

To conclude this paragraph, we would like to stress that there appears to be a lack of consensus among different countries about how to implement Basel II within and across borders. This is especially relevant due to the potential implications for competitiveness and financial stability. More specifically the competitive effects of the differential regulatory treatment of financial instruments might result in allocative inefficiency, eventually reducing social value (Berger, 2006). At the launch of Basel II the debate about its usefulness and flaws is still ongoing and the ideas of Basel III are gradually awaken.

Now we have developed an understanding of the objectives and calculation of regulatory capital, the next paragraphs will go more into detail on economic capital.

III. ECONOMIC CAPITAL

Next to the regulatory requirements, financial institutions calculate their own economic capital reflecting the unexpected losses and true risk according to the specific characteristics of their portfolio (Jackson et al., 2002). Economic capital can be defined as the amount of capital necessary to support the real economic risk a financial institution faces. It is mainly used for internal risk management purposes, but has different applications. Depending on the objectives of the tool and availability of data, a different methodology is required.

Although regulatory capital and economic capital are different, they are both a reflection of the risks embedded in transactions. However, it is important to keep in mind that regulatory capital is not a substitute of economic capital (Araten, 2006 and Burns, 2005). Recent papers (Jackson et al., 2002; Elizalde et al., 2006 and Jacobson et al. 2006) argue that also under Basel II, regulatory and economic capital will have different determinants. The prevalent differences are partially induced by the different objectives regulatory and economic capital target, e.g. financial soundness and optimization of business strategies, respectively.

One of their main differences is the implementation of the actual calculations. Examples are the different underlying assumptions related to the granularity of the portfolio, the different correlations that may be considered in calculating risk, the use of caps and floors etc. The table below gives an overview of the main differences between regulatory capital and economic capital.

It should be noted that the calculation of economic capital within a financial institution and the observed differences with regulatory capital depend on the model and parameterization of model inputs. For a detailed comparative analysis of the existing credit risk models we refer to Crouhy et al. (2000) and Allen (2004). The table below includes some of the main features of KMV, Credit Metrics and Credit Risk+, which are assumed to be reasonable models to quantify economic capital (Crouhy et al. (2000)).

This table is not intended to give an exhaustive overview of all the features of the different credit risk models that exist, but rather to give an idea of some important differences between them.

Insert Table 1 About Here

Carey (2000) indicates that the success of Basel II in matching economic and regulatory capital will depend on the degree to which the IRB approaches will take into account portfolio differences related to maturity, granularity and risk characteristics. Up until now, the potential match between economic and regulatory capital requirements and the strength of the match remains practically unexplored (Jacobson et al. 2006). However, in order to further promote financial stability within and across financial institutions, and to avoid potential tensions between regulators and banks (Jacobson et al., 2006), it is important to identify the drivers behind regulatory and economic capital and to understand the strength of the match between both.

IV. CONCLUSION

In order to promote financial stability, regulatory authorities pay a lot of attention to setting minimum capital levels. This paper shows it is not that straightforward to find an accurate, easy to calculate capital ratio. Furthermore, the effect of capital regulation on both risk mitigation and level of capital seems to be highly contested. On top of the regulatory requirements, financial institutions calculate their own economic capital reflecting the unexpected losses and true risk according to the specific characteristics of their portfolio.

In spite of the fact that economic and regulatory are both a reflection of the risks embedded in transactions, they differ significantly in their calculations. Especially the way both types of capital incorporate diversification and concentration effects diverges.

Eventhough there is an extended literature about capital regulation and Basel II, to our knowledge, there is no paper that gives an overall picture about the determinants and challenges of both economic and regulatory capital. Furthermore the existing literature on economic capital is small and the theoretical comparison to regulatory capital remains practically unexplored. With this literature paper we fill this void.

A critical issue in assessing the impact of Basel II on future lending behaviour is understanding the relationship between regulatory and economic capital and more specifically to understand which of them is the binding constraint. Up until now the impact of Basel II on capital requirements, capital levels, capital arbitrage, lending behaviour etc has been estimated by different techniques. However, as from 2007 banks have started implementing it and only recently real data has become available and the true impact of Basel II can be assessed. So there is still a lot of empirical research to be done in this field.

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FIGURE 1

The three reinforcing pillars of Basel II

Pillar 1: Minimum Capital Requirement

-Treatment of Credit Risk
  -Standard Approach
  -Internal Ratings Based Approach
    *Foundation
    *Advanced
-Treatment of Operational Risk
-Treatment of Market Risk

Pillar 2: Supervisory Review Process

- Sound Internal Processes to Evaluate Risk (ICAAP)
-Supervisory Monitoring

Pillar 3: Market Discipline and Public Disclosure

-Semi-annual Disclosure of
  -Bank's Risk Profile
  -Qualitative and Quantitative Information
  -Risk Management Processes
  -Risk Management Strategy
-Objective is to Inform Potential Investors

FIGURE 2

The VAR approach under Basel II

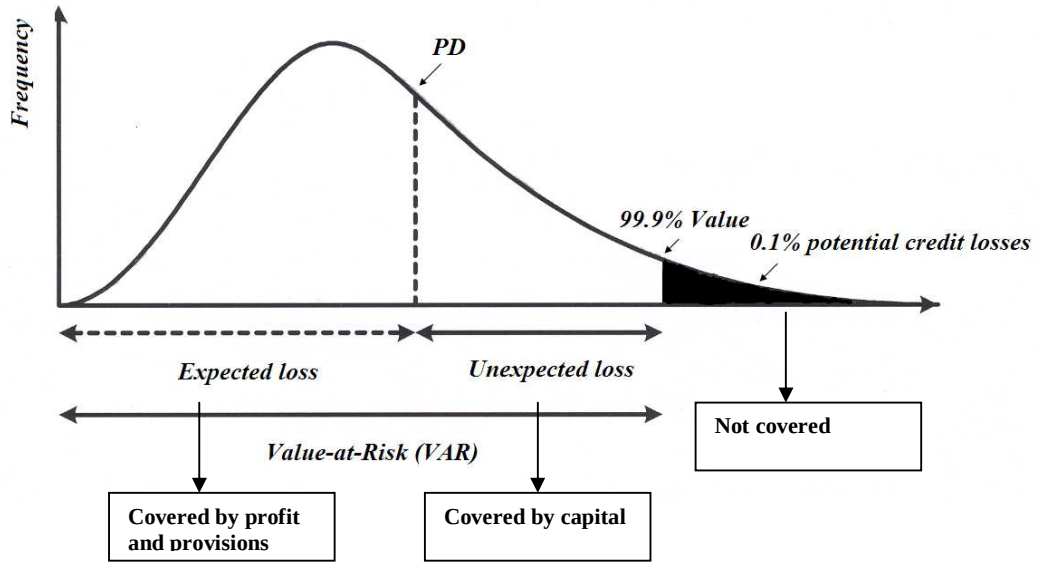

TABLE 1

Comparison between regulatory capital and economic capital

	Economic capital-CreditMetrics	Economic capital-Credit Risk+	Economic capital-KMV	Regulatory Capital
Definition of risk[8]	Mark-to-market (MTM)	Default mode (DM)	MTM or DM	DM
Purpose	Investment decisions, RAROC-calculations, risk-mitigating actions, consistent risk-based credit limits, and rational risk-based capital allocations.	Investment decisions, RAROC-calculations, risk-mitigating actions, consistent risk-based credit limits, and rational risk-based capital allocations.	Investment decisions, RAROC-calculations, risk-mitigating actions, consistent risk-based credit limits, and rational risk-based capital allocations.	Financial stability External reporting
Model approach	Credit migration (Merton based option pricing) approach	Actuarial approach Reduced-form model	Structural (Merton based option pricing) approach (multiple factor)	Structural approach (single factor)
Credit event	Credit migration	Random default rate (with Poisson distribution)	Distance to default	Default
Risk horizon	Can be chosen (does not require a one year horizon)	Constant time horizon (e.g. 1 year) or hold-to-maturity horizon	Can be chosen (from a few days to several years)	1 year
Risk drivers	Asset values (proxied by equity price)	Expected default rates (no assumptions about the causes of default)	Asset values	Standardised: external rating IRB: depending on model
Data issues	Likelihood of (joint) credit quality migration, valuation estimates Data: transition matrix, credit spreads, yield curve, LGD, corr and exposures)	Parsimonious data requirements (mean loss rates and loss severities) Data: default rate, volatility, macroeconomic factors, LGD and exposures	Data: equity prices, credit spreads, corr and exposures	Standardised: external rating IRB: depending on model
Confidence level	Based on target rating of FI, E.g. AA- (= 99.95%)	Based on target rating of FI, E.g. AA- (= 99.95%)	Based on target rating of FI, E.g. AA- (= 99.95%)	Based on target rating of A- (=99.9%)

[8] MTM models also include credit migration risk, DM models only distinguish between default and non-default.

Risk classification	Ratings (credit homogeneous issuers within one rating class and transition probabilities are based on historical frequencies[9])	Exposure bands	Distance to default and expected default frequency (EDF) (issuer specific and a function of capital structure, volatility of asset returns and current asset values)	Ratings
PD, LGD, EAD	Basel II models, R-squared and maturity -PD Full ***Maturity***	Basel II models, R-squared and maturity -PD Full ***Maturity***	Basel II models, R-squared and maturity -PD Full ***Maturity***	Basel II model -***PD*** subject to min of 0.03% for all asset classes except sovereigns -Downturn ***LGD*** -***Maturity*** **remaining contractual tenor:** -floored at 1 year, capped at 5 year -not applicable to retail
Recovery rate	Variable (Beta distribution) (taking into account uncertainty)	Constant	Constant or random	Constant
Valuation	Discounted value of future CF beyond one year and discount factor is the forward yield curve	Not used	Option pricing methodology applied to contingent cash flows; more specifically the Martingale approach (discounted expected CF based on risk-neutral probabilities)	Standardised: not used IRB: depending on model
Interest rate	Fixed credit spread	Constant	Constant	Standardised: not used IRB: depending on model
Income	Not used	Not used	Risk-free rate and expected loss as proxy for expected income	Not used

[9] KMV has shown that this does not hold in reality and might result in an adverse selection of corporate customers in banks (Crouhy et al. (2000)).

Correlation	Based on joint probability of multivariate normal asset returns(determined by firm specific, country and industry factors)	Assumption of independence or correlation with expected default rate	Based on joint probability of multivariate normal asset returns (determined by firm specific, country and industry factors)	Simple, parameterized Does not use industry/country
Concentration	Recognised	Not recognised	Recognised	Not recognised