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General Principles of Credit Risk Assessment

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Abstract: Credit risk is at the heart of banking concerns today. However, granting credit is a complex act; it is linked to risks whose coverage becomes a safeguard principle. In this context, it is necessary to carry out assessments in order to limit these risks.

Our study has made it possible to show, on the basis of the work of the Basel Committee, the relevant valuation method with regard to the requirements of Basel II and Basel III. For this purpose, the “standard” and “IRB” methods were used.
Keywords: Bank, credit, risk, investment credit, credit risk, rating, probability of default.

Introduction:

The revised system applies, on a consolidated basis, to banks with an international dimension. Supervision on a consolidated basis is best able to preserve the integrity of the capital of institutions with subsidiaries by eliminating their double counting. The scope of the system now includes, on a fully consolidated basis, any holding company at the head of a banking group, to ensure that risks are taken into account at group level. “Banking group” means a group that carries out banking-dominated activities; in some countries, a banking group may be licensed as a bank.

The system also applies to all banks with an international dimension, at each level within the group, also on a fully consolidated basis (see the diagram at the end of this part). A transitional period of three years is provided for countries where such full consolidation at the intermediate level is not currently required.

In addition, one of the main objectives of banking supervision being the protection of depositors, it is essential to guarantee that regulatory capital is easily mobilized for their benefit. With this in mind, banking supervisors should ensure that each institution has adequate capitalization at the individual level.

Section 1: General information on risks

1. Risk: definitions and typologies

1.1. Definition and identification of risks related to the company's activity:

According to Petit Robert (2012), risk is defined as “a more or less foreseeable possible danger”. According to Besson and Possin, (2006); “Risk designates a well-identified danger, associated with the occurrence of an event or a series of events, perfectly describable, which we do not know if they will occur but which we know are likely to happen". According to Bressy (2004); “Business risks are all events that may occur that are likely to reduce its profitability, or even call its existence into question. These may be threats that materialize, errors in management or forecasts or even the occurrence of unfavorable hazards”.

These definitions make it possible to account for the existence of common concepts linked to the notion of risk. Risk is defined there as a danger that is identified without ambiguity, associated with the occurrence of an event whose occurrence is probable. The two important elements are the identification of the hazard and the probability of occurrence of the event.

Before presenting the different definitions, it is necessary to make the difference between systemic risk and specific risk. According to Vernimmen (2012), a systemic risk is a risk that can endanger the survival of an entire financial system, of the economy as a whole. It is unavoidable and unmanageable at the business level. The specific risk, also called intrinsic risk or idiosyncratic risk results only from particular elements of the company which can result, as for them, from a bad management and from an economic or financial event.

We owe the first theory of risk to Frank Knight (1921).

His theory is often presented as making the link between Adam Smith's idea of risk (1776) and JM Keynes's notion of uncertainty (1936). Knight distinguishes risk, from the Latin *Resecum* “that which cuts”, from uncertainty, from the Latin *Incertus* “which is not fixed, determined in advance”. According to this author, risk designates a situation where the possibilities of the future are known and probable. In contrast, uncertainty designates a situation where we are unaware of all this. He therefore distinguishes between risky situations (where the probability distribution of the possible cases is not known) and uncertain situations (where the possible cases are not even known). A Knightian uncertainty is therefore a situation where not only is the future not known, but cannot be. Thus, we can speak of risk for an investor who speculates on the price of shares or for an insurer who offers coverage against fire. While the problem of space exploration or that of orphan diseases represent situations of uncertainty.

Knight has also developed a first typology of risks in business. He thus distinguishes pure risk from speculative risk.

1. Risks are said to be pure because their occurrence essentially results from events beyond the company's control. The realization of these events can only have negative financial consequences. Pure risk is also called operational risk. For example ; bad weather, fire, internal or external fraud by customers. The handling of this type of risk is covered by insurance.
2. The risks are said to be speculative, genuinely resulting from the decisions of the company. They are also called financial risks. It is a risk to which the company exposes itself voluntarily, for example; investing in a financial asset, speculating on exchange rates… The consequences of this type of risk can be negative or positive. Dealing with speculative risks is the very purpose of management.

Speculative risks can be broken down into a quantity of risks. There are many typologies in the literature. In the rest of this work, the typology proposed by Hull (2007) will be retained.

It should also be noted that financial companies experience other speculative risks such as liquidity and volatility risks, but this category of companies does not fall within the scope of this research. !

Market risk or financial risk concerns variations in the prices of various media and their effects on the value of the company's positions, including general market risk and risks specific to the sector of activity. The typology proposed by Hull (2007) breaks down financial risk as follows:

1. Commodity risk: it is linked to the volatility of commodity prices.
2. Exchange rate risk: this is linked to the possibility of a change in the conversion rate between two currencies.
3. Interest rate risk: this is determined on the debt market by the game of supply and demand for a security.

Finally, it should be noted that the company, beyond operational and financial risks, knows other types of risks that can be grouped under business risk.

Business risk can be broken down into:

1. Commercial or counterparty risk: it is linked to all the elements that influence the turnover of a company. It refers to the diversity of the clientele: The more the company is dependent on a small number of clients, the more fragile it is. In the same way, it includes the failure of one or more suppliers.
2. Production risk: it is linked to the company's production structure, which is used to determine the cost price of its products and ensures its degree of competitiveness. It understands the production cost risks, the quality and reliability risks of its products and the risk of lack of research and development. In this case the company is dependent on the innovations of its competitors.
3. Regulatory or legal risk: related to relationships with counterparties (capacity, authority, suitability), contract drafting and documentation standards, as well as risks of non-compliance with regulations. A risky legal situation exists when contracts or regulatory obligations are not applicable or not fully fulfilled.

1.2. Risk measurement:

In a Knightian paradigm, risk designates a situation where the possibilities of the future are known and probabilistic. In this sense, after having clearly defined the risks that a company knows or can know, it is necessary to know the probability of occurrence of these risks or the probability distribution associated with them. This amounts to being able to measure the realization of this risk.

Moreover, and in order to choose the appropriate risk management strategy, it is necessary and essential to estimate the real volatility of financial flows, and therefore to measure the risk.

In this paragraph, it is not a question of making an exhaustive presentation of risk measures, but of the main models and associated measures for measuring risk in the company. We will present two models of risk measurement in the company, the CAPM and the VaR.

1.2.1. CAPM:

The measurement of risk originated with that of financial theory. The birth of this theory is associated with the work of Bachelier (1900). But it was only with the work of Markowitz (1952) and Sharpe (1970) that the first work on risk was really conceptualized and led to the development of the CAPM and APT models.

In these models, risk is a function of the correlation between the assets that make up the portfolio. This modeling is based on several assumptions. Two of these fundamental assumptions concern the nature of agents' preferences and the normality of stock market return distributions.

The first hypothesis is necessary to formalize the investor's choice problem faced with a risky choice. However, it is difficult to accept that a financial asset is considered an inferior good (Pratt, 1964, Arrow, 1970). It is also difficult to explain the choice of risk averse agents (Friedman and Savage, 1948, Kahneman and Tversky, 1979, Golec and Tamarkin, 1998).

The second hypothesis makes it possible to express the expected utility as an exact function of the expectation and of the variance of the distributions of profitability and is theoretically based on the mean-variance approach.

However, the hypothesis of normality of distributions of profitability is clearly rejected in the literature by surveys and empirical observations (Engle, 1982, Bollerslev, 1986, Mandelbrot, 1997). The phenomena of asymmetry and leptokurticity are proven characteristics of empirical distributions.

The non-verification of traditional hypotheses has led to the outright rejection of the existence of a linear relationship between systematic risk and return. Alternative approaches to the traditional CAPM have been proposed (Harvey and Zhou, 1993, Fama and French, 1996, Fand and Lai, 1997, Hwang and Satchell, 1999, Harvey and Siddique, 2000,

Dittmar, 2001, Pedersen and Satchell, 1998).

1.2.2. Value at Risk (VaR):

The abandonment of risk measurement by the CAPM resulted in the development of a broad reflection on risk measurement. Following the criticisms of the said model, the risk must be measured and approximated by a distribution of probabilities linked to the risky variable. So it is the search for methods for calculating and estimating robust distributions that underlies the new measurements.

The publication of the article on the valuation of options by Black and Scholes (1973) and the creation of the CBEO (Chicago Board Options Exchange), the same year, mark the start of an intense development of research on the valuation of products. derivatives. From the 1980s, the extensive use of derivatives as a risk hedging tool made companies (banks) aware of risk and new statistical tools were developed to help them manage credit risk and select clients.

In 1994, the firm JP Morgan published a new risk measurement method; the Value at Risk or value at risk. This method was first extended to the entire financial community and then applied to much larger fields. It is widely distributed among both professionals and academics.

This risk measurement model is based on an estimation of volatility. This indicator is defined as the loss that a position risks incurring at a given time horizon and at a certain level of probability (Jorion, 2000). It is calculated by the quantile at a desired level of probability on the distribution of losses at a horizon T. Given these parameters, there are a variety of measures for different holding periods (from one to ten days) and levels confidence from 95% to 99.9%. Thus, for the same variable, the risk measured by a 95% VaR over one day is five times lower than the risk measured by a 99% VaR over ten days.

Three methods of calculating VaR are used by companies.

We thus distinguish; parametric VaR, historical VaR and Montécarlo VaR.

Each of these methods differs by the nature of the data used, by the simulation method and by the representation of the universe of risks and positions (Cougnaud, 2007).

VaR is thus a synthetic indicator that reflects the maximum loss for a given level of risk and a given time horizon. Nevertheless, from one company to another, VaR models are based on very diverse methodologies and assumptions in order to circumvent observability difficulties and computation time constraints. Because of this heterogeneity, the comparison as the aggregation of VaR must be considered with the greatest caution (Cougnaud, 2007).

In conclusion, VaR is currently a reference measure of aggregate risk taking. It should also be noted that researchers in finance and risk management are developing more and more indicators, which are more consistent, taking more account of the reality and needs of the company to measure volatility. Thus, in addition to “classic” VaR, we observe Earnings at Risk, Profit at Risk and Conditional VaR (CVaR). The latter is defined as the average of the worst which, unlike VaR, takes into account all extreme losses (Taillard, 2006).

2. Enterprise risk management strategy (ies):

Since risk is inherent in any human enterprise, risk management is a very old activity in the business world. It is as much a matter of day-to-day management as it is of strategy, its impact being able to call into question the very existence of the company.

2.1. On corporate risk management:

Risk management is ranked by financial executives as being among the most important issues in the management of corporate finances (Rawls, Waite, Gharles. Smithson, 1990). Financial risk management is the subject of an abundant literature and many researchers have invested in the subject.

For a long time humanity in general and managers in particular have developed philosophical approaches to apprehend risk. The mathematization of risk management, on the other hand, is a recent phenomenon.

This approach to risk in the company by the mathematical tool is linked to the progress of methods developed by economists and managers. These methods of managing risk in business stem from the uncertainty of future cash flows. Furthermore, the development of calculation methods and financial theories allow companies to estimate the volatility of these flows (Tirole, 2006). Thus, for about twenty years, rigorous theoretical foundations of risk management have been put in place.

Recall that the theoretical debate on risk management arose following the introduction of market frictions by the classic model of Modigliani and Miller (1958), concerning the impact of the financing policy on the value of the 'company. These authors maintain that, under certain hypotheses, the differences in profitability linked to the financial structure of the company exactly correct the differences in risk that it induces. Thus, in the context of a perfect market, the value of a company depends exclusively on its activity and its investment decisions, regardless of the mode of financing used. Therefore, investment and financing decisions are completely separate. In efficient markets, changes in the financing structure do not affect the value of the firm as long as the total cash flow generated by the firm's assets is not changed by the financing structure. This model is validated by showing that individual investors can arbitrate any situation of imbalance by going into debt and by replicating any choice of indebtedness made by their companies.

This model implies the existence of a perfect financial market which is based on the following very restrictive assumptions:

- Absence of taxes for companies and for individuals.
- There is no fixed rate loan or borrowing limit for all agents.
- Bankruptcy costs are nil.
- Lack of information asymmetry between agents.
- Absence of conflicts of interest: The managers manage the company in accordance with the interests of the shareholders.

Modigliani and Miller's theorem was initially applied to the analysis of the choice of financial structure, however, it can be applied to other aspects of financial strategy, notably hedging policies, being more general. An analogous reasoning by arbitrage makes it possible to assert that each investor can hedge by holding a diversified portfolio or by taking positions on the derivatives market to achieve the expected balance between risk and return. Therefore, no one would agree to pay a premium to acquire the securities of a company on the grounds that it manages its financial risks.

Thus, there is no need for companies to implement risk management strategies intended to give them a particular risk profile since their shareholders can, by themselves, diversify their investments. In other words, if risk management decisions do not affect the cash flows generated by real assets, then in the absence of market frictions they have no impact on the value of the company.

Empirical research on the subject has successively or jointly relaxed the neoclassical hypotheses of Modigliani and Miller. Thus, through various surveys, other researchers (Jensen, Meckling, 1976, Bradley, Jarell, Kim, 1984, Baker, Wurgler, 2002) have verified that the financial structure directly influences the value of the company and that a highly indebted company could have less value than another "healthier" company, all other things being equal and therefore the value of the company remains a function of its financial structure.

In the real economy, the company is an entity open to different financial and monetary flows. The value of the company is calculated by discounting all of its future cash flows. The company's objective is to manage its financial flows, which will lead to its growth or, on the contrary, its bankruptcy. However, cash flows are volatile and variable, as they depend on various factors such as the market, regulations, the technology used, etc. All these factors are not always controlled by the company. At the same time, this variability can increase or decrease depending on the strategy, management choices or corporate governance. Thus the characteristic of the management of the company lies in its financial structure which will determine the “sequences of payment” or management of its financial flows (Tirole, 2006). When the company is entirely equity financed, all of these cash flows accrue to the shareholders. When the company issues both debt securities and shares, it undertakes to divide the cash flows into two categories. The distribution of the different securities of the company is called the capital structure or the financial structure of the company.

Thus, companies should no longer manage the volatility of financial flows to reduce it because investors can diversify their risks in their portfolio, but take advantage of this volatility to increase their profit and to move from risk control to "real » risk management (Léautier, 2007). The value creation potential of risk management is still largely untapped.

2.2. Risk management towards the risk management strategy:

The use of derivatives or risk management products is now widespread, financial innovation continues to design new and more complex products (Shimpi, 2002). The ISDA (International Swap Dealers Association) indicates in its 2009 report that 94% of the 500 largest American companies (Fortune 500) use derivatives: 93.6% to manage the exchange rate, 88.3% to manage the interest rate and 50.9% to manage the price of raw materials.

However, this abundance of financial tools is not without consequences. Facts and current affairs constantly remind us of the case of companies that have distinguished themselves by their risk management practices, the consequences of which have been disastrous;

Mettallgesellschaft (1994), Baring (1995), Enron (2001), Worldcom (2002). These companies have in common poor risk management and poorly evaluated positions on derivatives, the consequences of which have been to file for bankruptcy.

In the 1980s, financial companies (insurance and banking) set up risk management structures to better manage liquidity, the exchange rate and the interest rate. Today, many non-financial companies are investing in the risk management function and implementing enterprise risk management (ERM) processes. ERM is an integrated approach to risks seeking to break with a compartmentalised vision of risks (Culp, 2003).

In 2004, the COSO published a report defining a reference framework for risk management in the company (see www.coso.org) where ERM is defined as a process implemented by the board of directors, the general management, the management and all the collaborators of the organization. It is taken into account in the development of the strategy as well as in all the activities of the organization. It is designed to identify potential events that could affect the organization and to manage risks within its risk appetite. It aims to provide reasonable assurance as to the achievement of the organization's objectives.

This frame of reference has had the effect of raising the risk management function to the highest level in the eyes of the administration, shareholders and the general public. Many large companies have set up an organization and a process dedicated to risk management. A professional qualification has also been put in place to train better risk managers. However, a study by the Economist Intelligence Unit (2010) concludes that risk management is an immature activity in many companies and that the risk management function is underinvested. Less than half of companies have invested in risk management processes and less than a quarter have invested in management training functions in the central risk management function. This situation is a serious paradox, where risk management remains immature and resource constraints constitute an obstacle for its development.

According to Standard & Poor's (2008), the managerial vision must integrate the most significant risks for the company. It must estimate their probabilities of occurrence, and their potential effects. This approach must also incorporate the frequency and nature of updates to the models used to identify these risks, their consequences on its liabilities and financial decisions. Finally, this vision must define the role of risk management in the development of the company's strategy.

A strategy is the creation or establishment of a unique position in an activity, by choosing to exercise it in a way that is different from that of its competitors. If there was only one ideal position, there would be no strategy (Porter, 1996). The risk management strategy goes beyond risk management, in the sense that it is defined as a structured and coherent approach to identify, assess and manage risks.

More specifically, the risk management strategy in the company is defined as the process that identifies, assesses and manages risks and uncertainties, affected by internal and external events or scenarios that could hinder the ability to an organization to achieve its strategic and strategic objectives with the ultimate goal of creating value and protecting shareholders and stakeholders (Frigo and Anderson, 2011).

This definition is based on six principles.

1. It is a process for identifying, evaluating and managing internal and external events and risks that could impede the achievement of objectives.

2. The ultimate goal is to create and protect shareholder and stakeholder value.
3. It is a main component and the necessary foundation of the whole organization of the enterprise risk management process.
4. As a component of risk management, it is by definition carried out by boards of directors, management and others.
5. It requires a strategic view of risk and examines how external and internal events or scenarios may affect the organization's ability to achieve its objectives.
6. It is a continuous and iterative process that should be built into the implementation of the risk management strategy.

2.3. Operational risk management strategies:

Operational risks present a great diversity leading to an excessive segmentation of these markets. Moreover, the levels of exposure to the various operational risks are very variable, being most often specific to each entity, their assessment on a market seems particularly delicate.

Operational risks can be transferred to insurance companies through specific contracts. This solution or strategy is preferred to cover those of these risks, which by their impact could jeopardize the survival of the company. Nevertheless, the trade-off between internalization and hedging of operational risks depends on the evolution of premiums on the insurance market, itself characterized by great cyclicality (Dionne, 2000).

Extreme risks falling under worst-case scenarios may, on the other hand, be more difficult or even impossible to transfer due to excessive premiums. Depending on the probability of occurrence and the associated losses, the attractiveness or possibility of risk transfer is therefore variable.

Credit risk can be defined by the potential loss borne by a lender following a change in the credit quality of one of its counterparties over a given horizon. Three components of credit risk can be distinguished: default risk, credit quality deterioration risk and collection risk.

1 **The risk of default:** corresponds to the counterparty's inability or refusal to ensure payment of its installments. Moody's retains the following definition of default risk: “Any failure or delay in payment of principal or interest”.

In such a situation, creditors are likely to suffer a loss if they recover only part of the amount stipulated by the debt contract;

2 **The risk of credit quality deterioration:** is linked to the debtor's loss of reliability, the risk premium on this borrower increases accordingly, the market value of this debt decreases, the debtor's rating decreases and the spreads demanded on this debt amount.

3 **Recovery risk:** corresponds to the uncertainty linked to the recovery rate after a default has been observed.

The risk of default or default is often referred to as “pure” credit risk. The notion of failure in risk management is different from that used in everyday language. In the second advisory document of the Basel Committee, this is defined as follows: “The failure of a given counterparty is assumed to have occurred if one of the four events has taken place:

1. The borrower can no longer honor its repayment obligations (principal, interest or commission) in full;
2. A credit event has occurred (for example, a specific provision);
3. The borrower has been in default for 90 days on one of his credits;
4. The borrower is in legal bankruptcy”.

Credit risk assessment aims to assess the expected probable loss of a loan portfolio over a given time horizon. This loss will have to be covered by a provision. The actual loss may be higher than the expected loss.

While it is never possible to know in advance a bank's losses in any particular year, a bank can forecast the average level of credit losses which designates the level of loss prevented.

The credit risk assessment also aims to assess the unexpected loss, which must be covered by own funds. The expected loss in the event of default (EL – *expected loss*) corresponds to the amount exposed to default (EAD – *exposure at default*) affected by the probability of default (PD – Probability of default) and the loss rate in the event of default (LGD – *Loss given default*).

$$EL = EAD \times PD \times LGD$$

Since the loss is random, it is necessary to estimate not only the average expected loss (*expected loss* – EL), but also the distribution of this loss. This distribution makes it possible to determine the *unexpected loss* (UL) which must be covered by equity. By way of illustration, if we consider a single loan with a binomial law of default PD and a loss P, the expected loss and the unexpected loss are easily calculated since the expectation of the loss is expressed as follows:

$$EL = E(P) = P \times PD + 0 \times (1-PD) = P \times PD$$

Credit risk assessment is based on models whose construction includes two phases. The first consists of collecting information on the constituent elements of the risk of each individual loan. This involves classifying loans into risk classes and determining the probabilities of default, the amount of exposure and the losses in the event of default for each class. The second phase consists of modeling losses and aggregating individual exposures to describe the risk of the portfolio as a whole. It is therefore necessary to take into account the correlations between the risks of different credits.

Section 2: Assessment of individual credit risk

The construction of the first level of a credit risk model comprises three steps.

The first is devoted to the allocation of individual positions in a set of risk classes defined by the internal rating system of the financial institution. In practice, most major banks have elaborate borrower rating systems: scoring systems for the various types of retail customers (individuals, professionals), expert financial diagnostic systems for businesses.

Banks can also use ratings provided by rating agencies or other financial information providers. These rating systems make it possible to classify loans according to their individual default risks.

The second step consists in measuring the probability that the credit migrates to another risk class. This step is crucial since the internal classification of credits and the probabilities of default and transition retained at this stage very largely determine the shape of the loss density function and therefore the dispersion of potential losses on the portfolio as well as the Va R [1].

This step also requires measuring the value of the exposure, in other words the value of each loan, in the various possible states, ie according to its membership in the different risk classes.

The third step is to determine the loss given default rate. This depends on the rate of recovery or recovery in the event of default, which itself depends on the nature of the credit, its maturity and the guarantees associated with it.

1.1. The probability of default (PD)

Credit risk is first and foremost the risk that the value of a loan will vary due to events that affect the quality of the borrower and his ability to repay.Its estimate is based on the loan default probabilities if we consider a market value model. To estimate these probabilities, several credit risk models can be used.

1-1-1- The Metrics credit approach

Credit Matrix was developed by JP Morgan in 1997 following the success of Risk Metrics. This model estimates the evolution of each issuer's spread over a one-year horizon. In this model, the ratings are provided by specialized agencies (Standard and Poors, Moody's, etc.).

The risk of loss is calculated in five successive steps:

1st ^{step} : Individual scoring

A score is first attributed to each counterparty according to its probability and its risk of bankruptcy. The external rating is published by the specialized agencies.

2nd ^{step} : The transition matrix

A rating transition matrix is then determined. This matrix consists of estimating for each rating level, the probability of migrating to each of the other possible ratings. Rating agencies regularly publish information relating to changes in issuer ratings. The tables describing the evolution of these ratings are called "transition matrices". They constitute a tool for estimating the conditional probabilities of default. The annual transition matrix describes the change in rating, over a one-year horizon, of a panel of issuers.

Consider the following annual transition matrix:

Rating	AAA	AA	HAS	BBB	BB	B	CCC	Default
AAA	90.81%	8.33%	0.68%	0.06%	0.12%	0.00%	0.00%	0.00%
AA	0.70%	90.65%	7.79%	0.64%	0.06%	0.14%	0.02%	0.00%
HAS	0.09%	2.27%	91.05%	5.52%	0.74%	0.26%	0.01%	0.06%

[1]This model is the subject of Chapter IV

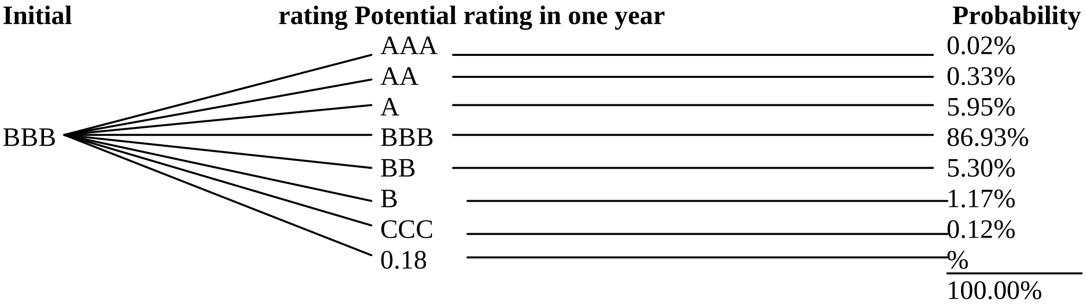
BBB	0.02%	0.33%	5.95%	86.93%	5.30%	1.17%	0.12%	0.18%
BB	0.02%	0.14%	0.67%	7.73%	80.53%	8.84%	1.00%	1.06%
B	0.00%	0.11%	0.24%	0.43%	6.48%	83.46%	4.08%	5.20%
CCC	0.22%	0.00%	0.22%	1.30%	2.38%	5.00%	64.85%	19.79%
Default	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100%

Source: CreditMetrics, Technical document, JP Morgan.

It should be noted that the CreditMetrics approach is based on three strong assumptions:

1. This matrix is stable over time, applies to all companies regardless of business sector or geographical location.
2. The probability of migrating from one class to another during a period is independent of events that have occurred in past periods. The probability of bankruptcy therefore does not depend on the past evolution of a security's rating. The probability of a company whose rating has recently been upgraded is assumed to have the same probability of default as a company whose rating has just been downgraded , if these two companies are assigned the same rating.
3. The third hypothesis is that the risk of default does not depend on the maturity of the security, or on other characteristics that may be specific to it.
4. Take the example of a bond rated BBB by Moody's.
5. Diagram 1 gives the probabilities relating to each of the eight states of the world that can be envisaged in one year. It is then a question of determining the value of the obligation in one year in the various possible states.

Figure 1: Rating transition probability of a BBB-rated bond



The probability for our asset with an initial rating of BBB to remain BBB after a period of one year is 86.93%, that of becoming B is 1.17%, that of defaulting is 0.18%.

3rd step: estimating the value of the securities

In each of the seven states where there is no bankruptcy, it will be possible to resell a title by realizing a capital gain or loss. To determine this capital gain or loss, the present value of the expected payments must be calculated. For this purpose, the discount rates provided by the zero-coupon rate curve (see Table 3) corresponding to each rating are used. These depend on the risk-free rates in effect for each maturity i and on the risk premium or ρi annual spread depending on the bond rating.

Table 1: term structure of forward rates (Risk-free rate plus risk premium)

Initial rating	**1 year**	**2 years**	**3 years**	**4 years**
AAA	3.60	4.17	4.73	5.12
AA	3.65	4.22	4.78	5.17
HAS	3.72	4.32	4.93	5.32
BBB	4.10	4.67	5.25	5.63
BB	5.55	6.02	6.78	7.27
B	6.05	7.02	8.03	8.52
CCC	15.05	15.02	14.03	13.52

Thus, the value of a security rated BBB whose future coupons amount each year to 6 euros for 4 years, the repayment at maturity being 100€, is expressed:

$$P = 6 + 6/1+4.1\% + 6/(1+4.67\%)^2 + 6/(1+5.25\%)^3 + 106/(1+5.63\%)^4 = 107.5€$$

We determine in the same way all the possible values of the security according to its migrations towards other ratings. These are the theoretical market values of the security in one year.

The eighth state considers a recovery rate at each emitter. To determine the value of the security in this situation, it is necessary to estimate the loss in the event of default (LGD: loss given default). CreditMetrics uses for this purpose the average recovery rates calculated by the rating agencies for the different ratings from historical data. This rate is 51.13% for securities rated BBB. In order to take into account the specific nature of each issue, in particular the guarantees associated with them, a recovery rate can be assigned per issue rather than per issuer.

In total, the different possible values of the BBB security are summarized in Table 4. This gives the value of a BBB loan in one year according to the rating and the probability of migration to another rating. The chart shows the strongly skewed distribution of the one-year horizon value.

Table 2: Value of a BBB loan in one year.

Rating	**probabilities**	**Value**
AAA	0.02	109.37
AA	0.33	109.19
HAS	5.95	108.66
BBB	86.93	107.55
BB	5.30	102.02
B	1.17	98.10
CCC	0.12	83.64
Default	0.18	51.13

Fourth step: calculating the VaR of an asset

The VaR calculation follows directly from this distribution:

$VaR_{1\%} = E(V_{1yr}) - V_{1yr,1\%} = 107.09 - 98.10 = 8.99$

$VaR_{5\%} = E(V_{1yr}) - V\ 1yr.5_{\%} = 107.09 - 102.02 = 5.07$

As shown in Table 5, under the assumption of normal distribution with $\mu = 107,09$ and $\sigma = 2,99$, the VaR would be estimated at 6.97 [$VaR_{N,\ 1\%} = 2.33\ \sigma$] which is a very distant approximation of the 1% VaR, because of the strong asymmetry of the distribution.

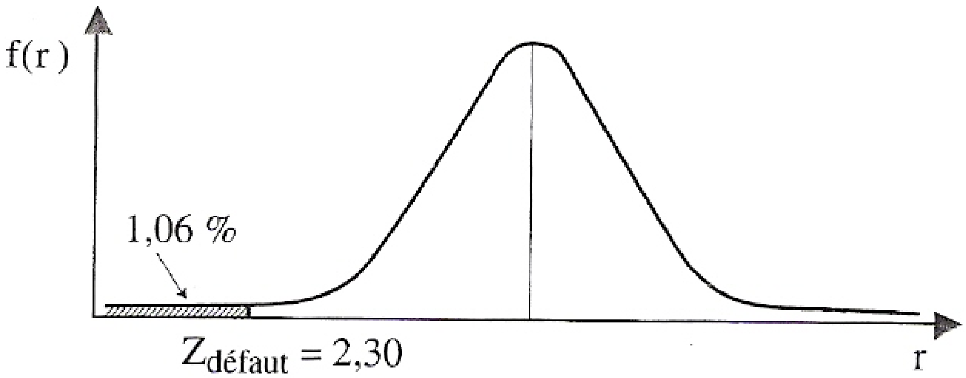
Table 3: VaR on credit risk with and without normality assumption

	Quantile at 1%	Quantile at 5%
Distribution VaR	8.99	5.07
VaR normality	6.97	4.93

Fifth step: calculating the VaR of a portfolio

In the case of a portfolio, CréditMetrics offers a distribution of rating statements attached to a given horizon, based on historical transition matrices and the correlation between bond prices. The market value of the issuer's equity makes it possible to approximate this correlation by calculating for each level of return, using the Merton model, the corresponding probability of bankruptcy. It is then sufficient to identify on the following graph the probabilities of bankruptcy corresponding to a change in rating.

Chart 2: Probability of default for a BB-rated bond



From the current rating, we deduce the probability of bankruptcy and the transition table (see Table 6).

Table 4: Probability of bankruptcy and associated distribution threshold

Rating in 1 year	**Probability of transition matrix for BBB rating**	**Threshold** $\frac{\sum_r}{\sigma}$
AAA	0.03%	3.43
AA	0.14%	2.93
HAS	0.67%	2.39
BBB	7.73%	1.37
BB	80.53%	-1.23
B	8.84%	-2.04
CCC	1.00%	-2.30
Default	1.06%	

What happens for a portfolio comprising several assets? For two assets, it is possible to simply calculate the joint probability that asset i will be rated BB in one year and asset j will be rated A according to the bivariate distribution which depends on the variance covariance matrix:

$$\Pr\left(Z_{BB} < r_j < Z_{BBB}, Z_A < r_j < Z_{AA}\right) = \int_{BB}^{BBB}\int_{A}^{AA} f\left(r_i, r_j, \Sigma\right) dr_i\, dr_j$$

It is thus possible, for a given correlation between assets i and j, to calculate the joint probabilities of rating changes shown in Table 7.

Table 5: Transition Credit Metrics Matrix attached at 1 year

A rated company								
BB company	**AAA**	**AA**	**HAS**	**BBB**	**BB**	**B**	**CCC**	**Default**
AAA	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
AA	0.00%	0.01%	0.13%	0.00%	0.00%	0.00%	0.00%	0.00%
HAS	0.00%	0.04%	0.61%	0.01%	0.00%	0.00%	0.00%	0.00%
BBB	0.02%	0.35%	7.10%	0.20%	0.02%	0.01%	0.00%	0.00%
BB	0.07%	1.79%	73.65%	4.24%	0.56%	0.18%	0.01%	0.04%
B	0.00%	0.08%	7.80%	0.79%	0.13%	0.05%	0.00%	0.01%
CCC	0.00%	0.01%	0.85%	0.11%	0.02%	0.01%	0.00%	0.00%
Default	0.00%	0.01%	0.90%	0.13%	0.02%	0.01%	0.00%	0.00%

Correlations are estimated using a multi-factor analysis by grouping companies by country and sector. For portfolios comprising many lines, it is faster to use the Monte-Carlo method to randomly select the returns of assets respecting the correlations. With N scenarios, if the number of scenarios Np below this quantile is greater than 20, the estimation interval for the number of scenarios below this p th quantile estimated with a confidence interval α , is given by:

$$Np-\alpha\sqrt{Np(1-p)} >< N\overline{p} < Np+\alpha\sqrt{Np(1-p)}$$

Finally, the risk exposure for different financial instruments should be calculated. For credit lines, the exposure changes depending on the amount of credits put in place. For *swaps* , *forwards* and other market instruments, the risk varies according to shocks to market variables. The revaluation of a *swap* in the different rating states of the counterparty is naturally more complex than that of a bond or a loan. Indeed, a credit loss appears when two conditions are met: the counterparty faces a rating change and the counterparty is liable on a net present value basis of the *swap* . In practice, CreditMetrics estimates the *swap* as a risk-free *swap* minus the cost of risk. The value of the risk-free *swap* results from discounting the future flows of its two branches. For the cost of risk, it is estimated for each rating level by estimating the remaining flows and a recovery rate.

1-1-2- The CreditRisk+ approach

Since the early 1990s, the Crédit Suisse First Boston group has endeavored to develop new credit risk management techniques. CreditRisk+, which makes it possible to model the loss in value of a bond portfolio following the failures of the companies that compose it, was created in December 1996. The approach implemented is inspired by the model of Duffie and Singleton (1991) . Unlike CreditMetrics, CreditRisk+ only focuses on non-recoveries of the bond portfolio and neglects the loss in value due to rating changes. The approach is based on a multifactorial modeling of the probability of default, the correlation between default states being then explained by the dependence of the financial situation of firms on common variables. The method requires simulating the joint changes in these sources of risk, taking into account the correlations that link them. From these changes, we deduce the potential exposure of the portfolio at any time. Random draws are made not only on market variables, but also on sources of credit risk and on recovery rates. From this we deduce at any time the issuer that has defaulted and the recovery rate relating to this issuer at the time of the default. One of the peculiarities of CreditRisk+ is the absence of explanations or at least hypotheses on the causes of borrower default. Defaults occur through a sequence of events such that it is impossible to predict when they will occur and the total number of borrowers who will default.

The exposure to default losses arises from a large number of observations. As a result, the best statistical law for modeling default risk according to the CreditRisk+ approach is Poisson's law.

The CreditRisk+ procedure comprises three steps: estimating the default frequency of each borrower, assessing the size of the loss in the event of default, assessing the distribution of losses for the entire portfolio. For the estimation of default frequency, the probability that *n* bonds will default during the period considered is given by:

$$P(n)=\frac{\mu^{n}\ell^{-\mu}}{n!}$$

Where μ is the expected default rate for the time period considered and n is the number of bonds in default.

1-1-3- The KMV model

It is a credit risk assessment model, based on the value of the company.

Unlike Credit Metrics, which only focuses on estimating conditional probabilities of default and exposure at default based on market spreads, this model relies on stochastic modeling of asset values, which allows establish a distribution of the difference between the value of the assets and the value of the debt.

Moody's KMV (see Grosbie and Bohn, 2003) extracts probabilities of default at a given horizon from stock prices, which are available for a large number of companies and the permanent capital of these companies is known. Thus, it is possible to extract probabilities of default from stock prices.

Moody's KMV assumes that the permanent capital of an issuer consists of long-term debt (with a maturity longer than the chosen horizon) which is denoted by "LT" and short-term debt denoted by "ST", then the point of default is calculated with a combination of long term debt and short term debt.

Indeed, the default point according to Modeling Default Risk (see Grosbie and Bohm, 2003):

Fault point ("X") X=ST + 0.5 $\times$LT if LT/ST < 1.5

X=ST + (0.7 - 0.3 $\times$ST/LT) $\times$LT otherwise

In the Merton model, the PD is: PD= N (-DD)

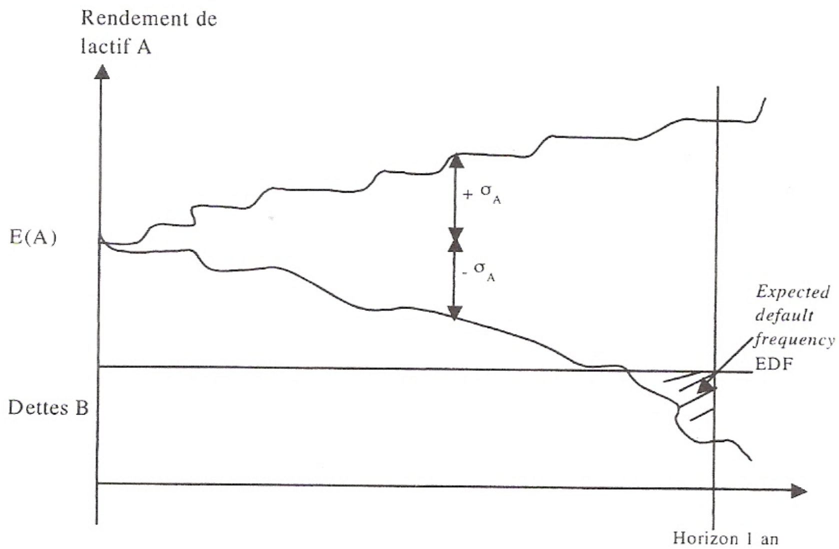
With $DD = \left(\frac{\left[\log(V_t) - \log(X) + \left(\mu - \sigma^2/2\right) \times (T - t) \right]}{\sigma\sqrt{T-t}} \right)$

N ( ) = reduced centered cumulative normal distribution
V_t = market value of the firm at t=0
X = fault point
σ = volatility of the firm's assets
μ = expectation of return on the assets of the firm

In fact, the value of the firm is estimated from the value of its assets. The idea underlying this modeling is illustrated in Figure 3.

Starting from an initial level of A in period default, the value of the assets at the horizon of the model (one year on the chart) varies between (A+ G_A) and (A- G_A).

Diagram 3: probability of default in the KMV model



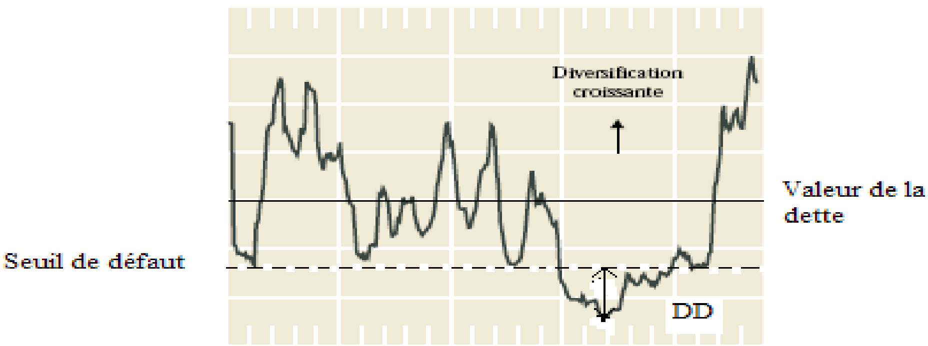
Estimating the value of assets and their volatility is based on establishing a system of two equations with two unknowns. For most companies, only the value of their shares is observable. To value these assets, KMV assumes that the company is only financed by shares, short-term debt and long-term debt. The first equation expresses the volatility of the share price, observed on the markets for listed companies, by a function of the Volatility of the value of the assets and of the value of the assets itself. The second equation expresses the stock price using the theoretical formula of a call on the value of the asset.

$\sigma_{E=}$ g (V_A, σ_A, X, c, r)
VE=f(V_A, σ_A, X,c, r)

Where X is the company's debt ratio, c the average coupon over the long term and r the risk-free rate. This approach also makes it possible to determine the probability (EDF) that the value of the assets will fall below that of the debts. It is represented on the graph by the hatched area under the line of debts B.

According to (Grosbie and Bohn, 2003 “modeling default risk”), and based on a history of observations, default does not occur as soon as the value of the assets falls below the threshold of the book value of the debt, but at a somewhat lower level, called the default threshold.

Graph 4: distance to fault in the KMV model



The relevant distribution estimated by KMV is therefore that of the difference between the value of the assets and the distance to default. Moody's KMV sees that the DD can be approximated by:

$DD = (V_A - X) / \sigma_A V_A$

The “EDF” is then calculated by: $EDF_t = E(-DD)$, see (Grosbie and Bohn, 2003). Where we denote E ( ). the function that traces DD for EDF_s.

After EDF's calculation, a transition matrix analogous to that of Credit Metrics can be constructed from EDF's classes that correspond to rating agency ratings (see Table 3).

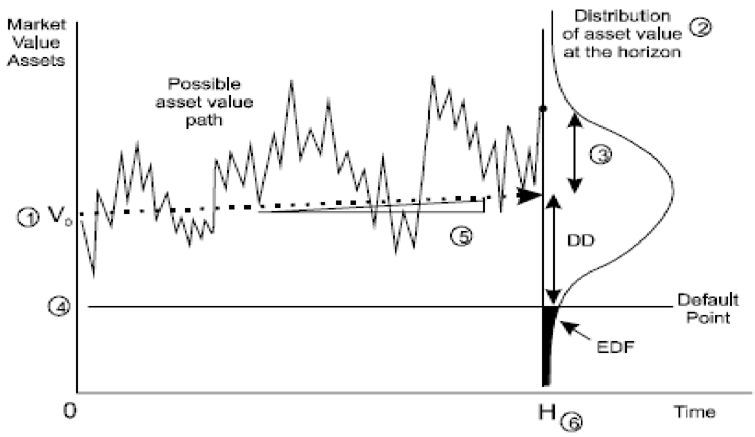
While generally this correspondence is used by patricians, it seems unreasonable, since EDF is a measure in a given moment of credit risk concentrated on the probability of default at the horizon of one year, while ratings are evolutions of a solvency cycle, they cannot therefore be reduced to one year of PD.

The interest of this approach comes first of all from the fact that it is based on theoretical foundations. Thus, the choice of the nominal value of the debt may seem surprising, insofar as the default rather results from a difference between the market value of the assets and the market value of the debt.

For Pascal Dumontier, Denis Duprès (2005), the conceptions of this approach legitimize the choice by a historical study of defaults, which shows that the chosen variable (the value of the assets minus the nominal value of the debt) is a good estimator of the default. Its interest also comes from the fact that if it can apply to any listed company, it can also be extended to unlisted companies, provided that we have information on changes in the value of their shares.

Furthermore, the probabilities of default provided by KMV reflect the expectations of equity investors and expectations concerning the evaluation of company results.

These probabilities can therefore be revised regularly. The limitations of the approach reside in the fact that the distribution of asset returns is supposed to follow a normal law, that it is necessary to have market data and that the differences between the types of debt are not taken into account. .



1-2- Exposure at default (EAD)

It corresponds to the one-year horizon estimate of the amount legally owed by the customer if he defaults. By convention, it is equal to the amount of credit utilization at the time of calculation of the ratio, plus a fraction of off-balance sheet commitments by application of a credit equivalent factor. In the advanced method, it is up to the bank to estimate this fraction, whereas it is provided by the bank controller in the standard or foundation (basic) method.

According to Pascal Dumontier, Denis Duprès (2005), in the case of traditional loans, the exposure to losses corresponds to the discounted total amount of the contractual flows still due. It is then necessary to adjust the exposure over time according to the terms of repayment or amortization of the loan or receivable. In the case of a mortgage guarantee, the exposure varies over time, since the debt decreases while the value of the guarantee (the property for example) is uncertain.

1-3- Loss given default (LGD)

Credit institutions shall estimate the value of LGD per grade or category of credit facilities, based on the effective average of LGD, taking into account all the default events observed for the different data sources (weighted average of defaults).

They use LGD estimates that are appropriate under the assumption of an economic downturn, if those estimates are more conservative than the long-term average. Insofar as a rating system is supposed to produce, over time, a constant effective value of LGD by level or category, the credit institution concerned makes to these estimates of the risk parameters by level or category, the adjustments necessary to limit the impact of an economic slowdown on its shareholders' equity.

Credit institutions shall take into account the degree of dependence, if any, between the risk relating to the debtor and that presented by the collateral or the provider of the collateral. Cases in which this degree of dependence is significant are treated with caution. In their LGD estimates, credit institutions also treat cases of currency mismatch between the underlying claim and the collateral with caution.

To the extent that they take into account the existence of collateral, LGD estimates are not based solely on the estimated market value of this collateral. They take into account the impact of a possible inability of the credit institution concerned to quickly take control of the collateral and to achieve it.

Section 3: Assessing credit risk on a portfolio

The second step in building a credit risk model is tomodel the uncertainty of future losses over the chosen time horizon, not for a particular credit but for a portfolio of credits [2]. This step makes it possible to construct the density function of future losses and to estimate the VaR and the equity required to cover the risk exposure. The results obtained during this stage make it possible to implement a coherent policy for allocating capital and pricing credits. Knowing the probabilities of default or transition and the value of each individual position in the event of a class change, including in the event of default, the construction of the density function of future losses requires aggregating the individual positions to determine their risk to inside the portfolio, which naturally differs from their individual risk.

In a portfolio approach, it is important to take into account the correlations between losses on individual exposures. Over a given horizon, one year in most models, all the variables that condition the amount of losses can vary. This is the case, for example, of exposure in the event of default EAD, if the loan in question is covered by a bond whose market value fluctuates according to changes in interest rates. This is also the case for loss given default LGD, if macroeconomic conditions affect the ability of lenders to call on guarantees.

But what determines the uncertainty or volatility of future losses is first and foremost the variability in the quality of the borrower. In other words, the probability of default PD must itself be considered as a random variable. At the horizon of one year, a borrower can change rating or risk class. This is why the modeling of the probability of default constitutes the essential element of a credit risk model.

All models for estimating credit risk assume that the probability of default is subject to the influence of risk factors specific to theeach borrower and the influence of factors common toall borrowers. The latter are sectoral factors, a crisis in a sector of activity affects all borrowers in this sector for example; geographic location factors, a regional crisis affects all borrowers in that region; macroeconomic factors, such as interest rates or the growth rate of gross domestic product. The variance of the probability of default of a credit is determined by the evolution of these risk factors. By way of illustration, a recession tends toincrease the probability of default, whereas the latter decreases in periods of expansion.

This is the reason why default probabilities or transitions between risk classes are not stable over time. It is therefore necessary to rely on a theoretical model, which associates changes in probabilities of default with

[2]The Basel II regulations do not authorize taking into account the effects of correlations between risks. It therefore imposes a simple summation of unit risks.

risk factors, to reproduce thedynamics of defects or transitions between classes. In short, constructing the loss density function on a loan portfolio consists mainly ofmodel the relationship between credit events and risk factors. The differences between the different credit risk models are mainly due to differences in the specification of the functional relationship between the probabilities of default and the risk factors and to the choice of risk factors. It is also necessary to consider the fact that if all the loans making up a portfolio are subject in an identical manner to the same risk factors, because the loan portfolio is insufficiently diversified, the amount of the actual unexpected losses will naturally be greater than if the portfolio is better diversified.

Conclusion

Controlling credit risk is not an additional task, but it is linked to the bank's strategy and requires the unification of several departments. HASAs such, this risk cannot be completely eliminated, but it can be managed in a way that meets the bank's objectives.

This management can bea priori at the level of the study of credit files (the methods -provisioning, the requirement of guarantees, and the tools for evaluating the credit risk), as it may bea posteriori by setting up a relevant system for monitoring credit and bank accounts and a collection service to recover the maximum possible debts from the bank.

In this regard, banks must necessarily increase their ability toimprove their profitability as well as their competitiveness in order to be able to properly ensure their sustainability.

Moreover, the behavior of taking credit in the bank can be influenced by the characteristics of the regulatory, legal and institutional environment and can degenerate into an excess of risk.

Thus, the institutional regulatory environment has a significant effect on excess risk, particularly the mechanisms for regulating banking activity and regulatory discipline. The effectiveness of the rule of law is also crucial for the efficiency and credibility. In turn, this excess risk amplifies the bank's probability of default.

Nevertheless, the international banking authorities have been able to evolve towards a prudential regulatory approach, from the Cooke ratio to the Mc Donough ratio. The latter, which is based on new rules and methods for measuring risk, has as its main objective to move towards a new, more effective management of credit risk, to better reorganize bank credit activity in order to ensure profitability and the long-term sustainability of financial institutions

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