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Credit risk assessment of SMEs on the internal rating basis

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Acknowledgement

Dedication

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Abbreviations

SME	Small and Medium-Sized enterprises
BCBS	The Basel Committee on Banking and Supervision
CR	Credit Risk
MR	Market Risk
OR	Operational Risk
IRB	Internal Rating Based approach
CBT	Central Bank of Tunisia
SA	Standard Approach
FIRB	Foundation Internal Rating Based Approach
AIRB	Advaced Internal Rating Based Approach

General introduction

Global banking activity underwent many changes during the 1980s. Three factors are responsible for this, namely the deregulation of financial activity, the instability of financial markets and increased competition between institutions. Banks had to expand their fields of activity by developing new businesses and products, which resulted in excessive risk-taking.

The awareness of the need for risk management has prompted the regulatory authorities to organize themselves within a new regulatory framework, defined by the Basel Committee. The Basel I Accord, introduced in 1988, limits banking risk management to the Cooke ratio. The basic idea is to require banks, operating internationally, to hold a minimum level of regulatory capital at all times as a hedge against credit risk. The new Basel II agreement follows on from the initial agreement in 2004 in order to better understand banking risks. Indeed, the tripartite structure of the new agreement refines, first, the calculations of regulatory capital requirements based on rating systems, and then obliges banks to ensure financial transparency, communication and data exchange with the various players in the banking circuit.

The revision of the 1988 agreement contributed significantly to the development of risk measures within banks in order to determine regulatory capital requirements. In terms of credit risk, the modelling alternatives are limited to five models, namely CreditMetrics, PortofolioManager, CreditRisk$^+$ or CreditPortofolioView. Brannan et al (2002) estimate that 80% of banks use at least one of these models (De Servigny and Zelenko, 2010). Nevertheless, the implementation of credit risk models remains dependent on the availability of reliable financial and accounting data.

In Tunisia, the transposition of international recommendations on banking risk management is limited to the solvency ratio, as defined in Basel I. The treatment of risks at the level of Tunisian banks is carried out in a classic and simple way. It consists of legal conditions and

financial ratios, covered by the circulars of the Central Bank of Tunisia. In addition, Central Bank Circular No. 91-24 of 17 December 1991 is the basic reference for risk management. Credit risk, being the first type of risk taken into account, is traditionally managed through the creation of provisions and the introduction of limit systems.

Under pressure from the International Monetary Fund, Tunisian banks are called upon to reduce non-performing loans and to make greater efforts to provision unproductive loans. In addition, the Central Bank of Tunisia has forced banks to set up collective provisions through the publication of circular no. 2012-08 of 11 January 2012 and the note to credit institutions no. 2012-08 of 2 March 2012 on the establishment of collective provisions to cover latent risks on all current assets and those requiring special monitoring.

Although credit risk has been the subject of great attention from the banking circuit, it is nevertheless necessary to develop new tools for more active management of this risk. Consequently, the regulatory authorities are required to define a new prudential regulation, which governs the activity of granting bank loans in Tunisia. The use of sophisticated risk management models such as CreditMetrics, CreditRisk$^+$ or others is an interesting avenue to explore.

In order to meet this objective, the purpose of our brief is to apply J. P. Morgan's CreditMetrics method in the Tunisian context. The aim is to enable Tunisian banks to comply with international standards in terms of credit risk management.

Compared to other credit risk models, the CreditRisk$^+$ model is best suited to the Basel II regulatory framework because it allows rating systems to be incorporated into the need to determine regulatory capital requirements. In addition, it considers that the data required for its use is both easy to use and simple. Another of its own properties, this model makes it possible to determine not only the overall risk but also the contribution of each counterpart to this risk, enabling the bank to pursue a more targeted recovery policy in terms of hedging against credit risk. The ultimate objective is to minimize the bank's overall credit risk.

In addition, this essay will be organized into four chapters. First, the first chapter will present the characteristics of international and national regulations in terms of credit risk management. Then, the second chapter will focus on the different measures and main models for assessing credit risk. The third chapter will focus on the general presentation of the empirical study framework and finally conclude with the display and interpretation of the results of the implementation of the CreditRisk$^+$ model in the Tunisian banking context.

Part I

Theoretical part

Chapter 1

Background and main concepts

Introduction

The prudential aspect of regulation has largely contributed to the emergence of risk management in the banking sector. It forced banks to put in place monitoring mechanisms and risk control in order to ensure the safety of the banking system and prevent bankruptcies.

Constantly evolving, prudential regulation has developed through the modification or removal of old rules or the introduction of new ones. It operates under the guidance of the Basel Committee and the national authorities. It covers credit risk, market risk and operational risk. All the regulations constitute a structure that reflects the institutions' risk management tools and procedures.

In the light of the above, the purpose of this chapter is to describe the main principles of both international and domestic prudential regulation and its main risk management provisions, including credit risk. It will be divided into three sections; The first section is intended to define credit risk and its main components. In the second section, we look at the international regulatory framework. We present the evolution of the Basel agreements with a focus on the structure of the Basel II agreement. Finally, the third section is devoted to the main national prudential rules instituted by the Central Bank of Tunisia.

1.1 Theoretical Concepts

1.1.1 Risk metrics : Theoretical concept

"Risk is an important concept in a number of scientific fields, yet there is no consensus on how it is to be defined and interpreted. Some of the definitions are based on probabilities, others on expected values, some on uncertainty and others on objectives. Some authors regard risk as subjective and epistemic, depending on the knowledge available, some regard it as aleatoric, due to the probabilistic character of certain parameters, while yet others give risk the ontological status independent from the person assessing it.

The situation has simply not been resolved in an authoritative manner. On the one hand, this certainly hinders efficient risk management and the development of the field, while, on the other, it is possible that there are rather good reasons for such a situation. Inevitably, specific areas require different methods, procedures and models of risk, for example, medicine and engineering. But the question remains whether these areas should have such disparate views on the concept of risk and uncertainty, when the challenge they face is essentially the same – creating a concept that describes the activity of the system resulting in outcomes different from the expected, desired or planned, or different from its objectives."*(Sotic and Rajic, 2015)*

In their article Sotic and Rajic reference the different ways of considering the risk :

- Risk is the measure of probability and the weight of undesired consequences (Lawrence, 1976).
- Risk equals the triplet (s_i, p_i, c_i), where si is the set of scenarios, pi is the likelihood of that scenario, and ciis the consequence of the scenario, $i = 1, 2, ..., N$ (Kaplan & Garrick, 1981).
- Risk equals the product of probability and severity (Wilson & Crouch 1982).
- Risk is a combination of five primitives: outcome, likelihood, significance, causal scenario and population affected (Kumamoto & Henley, 1996).
- Risk is a situation or event where something of human value (including humans themselves) has been put at stake and where the outcome is uncertain. (Rosa 1998).

- Risk is the expression of influence and possibility of an accident in the sense of the severity of the potential accident and the probability of the event (MIL-STD-882D, 2000).
- Risk is a combination of the probability and scope of the consequences (Risk Management Vocabulary ISO 2002).
- Risk is an uncertain consequence of an event or activity related to something of human value (IRGC, 2005).
- Risk equals expected damage (Campbell, 2005).
- Risk is the likelihood of an injury, disease or damage to the health of employees due to hazards (Law on Safety and Health at Work, 2005).
- Risk refers to uncertainty about and severity of the events and consequences (or outcomes) of an activity with respect to something that humans value (Aven & Renn, 2009).
- Risk is the effect of uncertainty on objectives (Risk Management, ISO, 2009)

1.1.2 Banking risks : Typology

1.1.2.1 Credit Risk

The credit risk is, in general, the risk incurred by the creditor to lose all or part of his claim due to the default or default of his debtor.
The credit risk is therefore inherent to the traditional activity of the banker who is, besides collecting deposits, to grant credit. It therefore naturally occurs in any financial asset (or commitment) of the investment portfolio of a bank.
From a prudential point of view :

- The **counterparty risk** is weighted and reported as the same as the credit risk, the main difference residing in the same way to calculate the amount of exposure;
- The **risk on incomplete transactions** is also weighted and reported in the same way as the credit risk, the main difference being the obligation to deduct, rather than weight, the amount of exposure from the 5th business day following the contractual settlement date;

- Only the **risk of settlement/delivery** receives a really specific treatment, as well as a dedicated reporting table, since the weighting is not a function of the quality of the counterparty, but only the number of days since the contractual settlement date.

Basel II proposes two approaches to determine the capital requirement for credit risk coverage :

- A **standard approach**, in which the capital requirement for credit risk coverage is calculated on the basis of percentages defined by the regulations;
- An **internal ratings-based approach**, in which the capital requirement for credit risk coverage is calculated by applying a regulatory formula whose parameters (probability of default, loss in case of default, but also, for the determination of the value at risk, conversion factor) are determined by the internal models that the institution uses to monitor and manage its credit risks, this approach based on internal ratings is itself even declined in two variants :
  - A basic IRB or "foundation" approach, in which only the first of the 3 parameters (PD) is determined by applying the internal models of the institution;
  - An "advanced" IRB approach, in which the 3 parameters (PD, LGD and CCF) are determined by applying the institution's internal models.

1.1.2.2 Market Risk

Market risk is, in general, the risk of suffering a loss due to an unfavorable change in the price of an asset, and this :

- That one possesses a certain quantity of this asset (long position) in which case one fears a fall of the price of the asset, or,
- That we owe a certain amount of this asset in which case we fear a rise in the price of the asset.

The market risk taken into account under Pillar 1 covers four asset classes (the derivative positions being treated as positions on the underlying assets) :

- Bonds, or debt securities (interest rate risk),
- Shares, or title deeds (equity position risk),

- Currencies (currency risk),
- Commodities (commodity risk).

Market risk on bonds and equities has two distinct components :

- **Specific risk** : This is the risk related to a change in the price of the instrument (bond or share) attributable to the issuer of the instrument; this risk is close to the credit risk in the investment portfolio, but has a wider scope in that it must be taken into account for both long positions (risk of a decline in the price as a result of the deterioration in the quality of the investment. the issuer) only for short positions (risk of price increase following the improvement of the issuer's quality);
- **General risk** : This is the risk linked to a variation in the price of the instrument (bond or share) for reasons unrelated to the issuer of the instrument (eg a general movement of interest rates).

The market risk regime in Basel II remains the Basel I regime adopted in 1996 (market risk amendment).
Basel II therefore continues to propose two approaches to determining the capital requirement for market risk coverage :

- A **standard approach**, in which the capital requirement for market risk coverage is calculated on the basis of percentages defined by the regulations;
- An **internal model approach**, in which the capital requirement for market risk hedging is calculated by applying internal mathematical models ("risk-in-value" models) that the institution uses for monitoring and management of its market risks.

1.1.2.3 Operational Risk

Operational risk is defined from a prudential point of view as "the risk of losses resulting from inadequate or failed processes, people and internal systems or external events, including legal risk".
These losses can be related to :

- Fraud, whether internal (e.g. **Nick Leeson** at Barings Bank in 1995, or Jérome Kerviel at Société Générale in 2008) or external (e.g. misappropriation of credit cards);

- Acts contrary to the laws or conventions concerning employment (e.g. discrimination) or security (non-compliance with standards);
- A breach of an obligation to a customer (e.g. sale of a product does not match the risk profile of the customer, or sale of a product by hiding the customer the real nature of the related risk);
- A natural disaster (e.g. earthquake, flood);
- Other external events (e.g. 9/11 Attack in New York);
- A breakdown or malfunction of computer systems;
- Transaction maltreatment (eg encoding error);
- etc.

Barings and the lessons of operational risk

On February 23, 1995, the stunned world learned of the bankruptcy of the prestigious British investment bank Barings and the arrest in Germany of Singapore-based star trader Nick Leeson, by whom the scandal came. At the time, as the head of the derivatives market on the Singapore Stock Exchange, Nick Leeson was responsible for organizing all transactions on behalf of clients of the bank, but also the back office and trading of the market.

The young 28-year-old then liked to speculate on the rise of the Japanese stock market by selling Nikkei index futures in order to make the most of the leverage effect. Without real control, he will begin to invest the funds of the clients in speculative operations not authorized, but known of the leaders of Barings. It quickly becomes, in the eyes of the profession, a renowned operator.

However, Nick Leeson could not predict the Kobe earthquake in January 1995 and the extent of its financial consequences. Convinced that the market will recover, he continues to buy new contracts to cover his first losses, seeking to control the Nikkei index in hopes of limiting its decline. In vain. The Japanese index continues its fall and leads with him Nick Leeson and Barings. The cumulative loss is estimated at £860 million, more than twice the amount of the bank's equity.

"Barings et les leçons du risque opérationnel", LA TRIBUNE

Basel II proposes three approaches to determining the capital requirement for operational risk coverage :

- A basic indicator approach, in which the capital requirement for operational risk coverage is equal to 15% of the arithmetic average of the operating result - calculated as the difference between the products (eg interests and commissions received) and expenses (eg interest and commissions paid) - for the past three years, the operating result being intended to be indicative of the extent of the operational risk incurred by the institution;
- A standard approach; in the framework of which the capital requirement for operational risk coverage is calculated as in BIA, that is always based on the operating result, but with two major differences :
  - The requirement is calculated by line of business rather than by legal entity (the requirement for a given legal entity being the sum of the requirements calculated by line of business), 8 lines of business being defined for this purpose (retail banking, commercial banking, asset management, etc.);
  - Each of these 8 lines of activity is assigned a coefficient of its own (between 12% and 18%) instead of the single 15% coefficient applicable in BIA;
- An advanced measurement approach, in which the capital requirement for operational risk coverage is calculated by applying the internal mathematical model that the institution uses to monitor and manage its operational risk.

1.1.3 Definition of SMEs

Definition of a business

Any legal or natural person exercising industrial, commercial, agricultural or any other profession as defined by the decree establishing the National business directory. In practice the directory units are identical for companies with a license from the general direction of tax control.

Definition of SMEs

In Tunisia there is no legal definition of (SME) but rather implicit definitions adopted by the upgrading program (PMN), the Small and medium corporate banking BFPME companies and

stock exchange. Indeed, following the presidential measures of May 2002, the PMN moved towards the small and medium enterprises with investment of less than three million dinars while BFPME (dedicated exclusively to SME financing) helps fund the creation of productive entities (excluding tourism and property development) whose total cost is between 80,000 and 4 million dinars or expansion projects (excluding tourism and property development) whose total cost (net assets and new investments) is between 80,000 and 4 million dinars.
As for the stock market, referring to the decree 77-608, as amended by Decree 2005 to 2397, it considers SMEs, companies whose criteria of net fixed assets and workforce do not reach the following thresholds :

- Four million dinars in regard to the amount of net assets
- 300 people regarding the total workforce.

In the case of Tunisia, the definition of SMEs retained in the context of the development of the business national directory refers to the number of employees hired and class in the small business category (PE), those employing between 6 and 49 employees in the medium-sized enterprises (ME) those employing between 50 and 199 employees and large companies (GE) 200 and more employees.

1.1.4 Financing SMEs

In the context of the Tunisian economy, bank financing remains the main instrument of corporate financing as the use of direct finance is relatively new. In addition, commercial banks remain the dominant actor, despite the development of a diverse range of financial institutions such as leasing, factoring, the SICAV, SICAR and SICAF. However, the issue of SME financing methods remains, which explains the steps taken to develop mechanisms and public support institutions to strengthen capital and long-term capital for SMEs : National Guarantee Fund FOPRODI the FONAPRAM, the Tunisian guarantee company SOTUGAR and corporate banking for small and medium enterprises BFPME.

1.1.4.1 The National Guarantee Fund (NGF)

The National Guarantee Fund (NGF) is intended to ensure the outcome of certain categories of lending by banks on their common resources or loans to SMEs and loans granted to all farmers against drought risk.

1.1.4.2 The Promotion and Industrial Decentralization Fund (FOPRODI)

FOPRODI task is to promote the advancement of entrepreneurs (new promoters); encourage the creation and development of SMEs and implement incentives for the decentralization of investment in the industrial sector.

1.1.4.3 The Tunisian guarantee company (SOTUGAR)

SOTUGAR Article 24 of Law No. 2002-101 of 17/12/2002 concerning the finance law for 2003, established a guarantee system for certain categories of lending by credit institutions, medium-sized enterprises in industry and services and certain categories of investments made by capital investment companies in risk capital of the companies concerned; This guarantee scheme is called "Guarantee scheme for loans to medium-sized enterprises in industry and services and participation in their capital".
Sharing the irrecoverable amounts between the guarantee scheme (SOTUGAR) and the Bank or the SICAR is carried out according to the following distribution :

- In the case of projects in the areas of regional development, the projects initiated by new promoters and those enjoying the support of incentive funds for innovation in information technology : 75% by SOTUGAR and 25% by the bank or the SICAR.
- In the case of other companies: 60% by SOTUGAR and 40% by the bank or SICAR.

1.1.4.4 The National Fund for Crafts and Small Trades' Promotion (FONAPRAM)

The purpose of the fund is to encourage the promotion of artisanal projects and small trades through an investment premium equal to 6% of the cost of the project or an endowment repayable over 11 years with a grace period not exceeding not the repayment term bank loans with a default interest rate of 4%.

1.1.4.5 Corporate Banking Small and Medium Enterprises (BFPME)

BFPME is dedicated to small and medium enterprises to help finance the creation of productive entities (excluding tourism and property development) whose total cost is between 80,000 and 4 million dinars or expansion projects (excluding tourism and real estate development) whose total cost (net assets + new investment) is between 80,000 and 4 million dinars. BFPME finance physical investment (excluding land) and intangible creation and at the extension by granting

medium and long-term loans.

The bank's mission is to complement the current funding mechanism and boost the investment rate of growth and support entrepreneurship by fostering the emergence of innovative projects and provide assistance and support necessary to facilitate the creation of SMEs and promote the development of existing SMEs by funding the expansion operations.

1.2 Understanding Basel international regulations

1.2.1 Basel Committee on Banking and Supervision (BCBS)

The BCBS was established in December 1974 by the central bank governors of the Group of Ten "G10" countries under the title of "Committee on Banking Regulations and Supervisory practices".

The Basel Committee meets regularly to discuss issues related to the prudential supervision of banking activities. However, it has no legal authority for surveillance and regulation: its role is limited to setting standards, defining principles, making recommendations. He produces neither regulations nor laws. It is therefore only indirectly, after (possible) transposition into national legislation, that these texts will have an impact on the effective control of banks.

The meetings of the Basel Committee usually take place at the Bank for International Settlements (BIS) in Basel, Switzerland, whose premises house its Permanent Secretariat.

The creation of the Basel committee coincides with a year of strong turbulence on the foreign exchange market : the year 1974 remains marked by the resounding bankruptcy of the bank **Herstatt**, in Germany, which highlighted the existence of a systematic risk on the foreign exchange market.

At the core of the problem was the huge exposure of the bank, estimated to be eighty times more than its exposure limit.

Collapse of the Herstatt Bank in Germany and creation of the Basel Committee [1974 - 1975]

The collapse of this medium-sized bank sparked a deep crisis in the foreign exchange market, on which it was very active. The New York interbank market came to a standstill, almost leading to the collapse of a number of other institutions.

The faulty strategy adopted by the bank while speculating the movement of dollar is understood to be one of the most important reason for such a huge liability.

The foreign exchange risk was thus three times as large as the amount of its capital. The special audit conducted by Federal Banking Supervisory Office (BAK red) prompted the management of the bank to close its open foreign exchange positions.

This bankruptcy brought to light the systemic risks related to the increasing internationalization of banks.

Shortly after this event, Peter Cooke from the Bank of England proposed setting up a committee of central banks and banking supervisory authorities, which became known as the Basel Committee.

Basel Accord, 1988

By the early 1980s, the committee had indeed realized a double situation whose combined effect could be catastrophic on the stability of the international banking system: on the one hand, there was a clear deterioration the solvency ratios of the major international banks and, on the other hand, a sharp increase in the credit risk incurred by these same banks on highly indebted developing countries.

Thus, in July 1988, a first scheme was launched, entitled "International Convergence of Capital Measurement and Capital Standards" but more commonly known as the Basel Accord or today **Basel I**.

1.2.2 Background of Basel I

Under the terms of the agreement, the governors of the central banks of the 12 countries, member of the Basel committee pledged to implement in their respective countries by the end of 1992, banks operating at the international level and established in these countries should have permanent regulatory capital of not less than 8% of their risk-weighted assets and liabilities on

a consolidated basis.

The solvency coefficient, known worldwide since then as the “ratio cooke” after the name of the chairman of the Basel Committee from 1977 to 1988 (W.P. Cooke, then Director at the Bank of England), was implemented in more than 100 countries around the world and still remains at the heart of the revised Basel II, even if, naturally, its methods of calculation have changed profoundly.

The cooke ratio was based on reporting the amount of available own funds (numerator of the solvency ratio) to the amount of the risk-weighted assets (solvency ratio denominator), and require that the ratio be not less than 8% (minimum coefficient).

$$Solvency\ Ratio\ =\ \frac{Tier\ 1 + Tier\ 2}{\sum RWA_{CR}} \geq 8\% \tag{1.1}$$

- $Tier\ 1$ **(Core Capital)** : Tier 1 capital includes stock issues (or shareholder equity) and declared reserves, such as loan loss reserves set aside to cushion future losses or for smoothing out income variations.

- $Tier\ 2$ **(Supplementary Capital)** : Tier 2 capital includes all other capital such as gains on investment assets, long-term debt with maturity greater than five years and hidden reserves (i.e., excess allowance for losses on loans and leases). However, short-term unsecured debts (or debts without guarantees), are not included in the definition of capital.

- RWA_{CR} : defined as the risk weighted asset of the bank, which are a bank’s assets weighted in relation to their relative credit risk levels. There are 4 risk categories with weights, which range from 0% to 100% :

  - 0% weighting for receivables from OECD Member States;
  - 20% weighting for receivables from banks and local authorities in OECD countries;
  - 50% weighting for receivables secured by a mortgage or real estate loan;
  - 100% weighting for all other assets, including customer loans

  Off-balance sheet commitments must be converted into "asset equivalent". In other words, the application of the weighting coefficients is preceded by the application of a conversion factor, reflecting the probability of the commitment being met.

The Market Risk Amendment, 1996

The 1988 Basel agreement dealt only with credit risk and the investment portfolio. This type of risk has been treated as a priority, insofar as it represents the risk inherent in the banker's traditional activity of bailing out the funds he has collected.
The market risk was perceived by the Basel committee as the second type of risk to be treated first, after the credit risk. And indeed, banks that carry out their trading activity in addition to their traditional deposit-taking activity are strongly exposed to this type of risk.
Then, in January 1996, the Basel Committee publishes a document entitled Amendment to the agreement on capital for its extension to market risks, the implementation of which is proposed for the end of the year 1997.
This amendment modifies the original agreement on three fundamental points :

- The capital requirement for credit risk is now supplemented by a capital requirement for market risk :
  - Interest rate risk
  - Equity risk
  - Foreign exchange risk
  - Commodities risk
- This new capital requirement for market risk can be determined on the basis of internal models previously validated by the supervisory authority
- A new category of regulatory capital, called "Tier 3", is introduced category only authorized to cover the capital requirement for market risk.

Following this amendment, the solvency ratio is as follows

$$Solvency\ Ratio\ =\ \frac{Tier\ 1 + Tier\ 2 + Tier\ 3}{\sum (RWA_{CR} + RWA_{MR})} \geq 8\% \tag{1.2}$$

1.2.3 Framework of Basel II Accord

The limits of the Basel I agreement have gradually emerged, since the risk measure devised by the regulator may differ substantially from the actual risk the bank faces.
Banks have indeed been tempted :

- to keep in their balance sheets the assets which, for a given capital requirement, are relatively riskier in their category, and whose return is consequently higher,
- to eliminate the assets of this same category whose real risk is lower (like a business loan whose rating is very good), and whose return is therefore lower.

In the same category, all assets receive the same weighting, as for example, 100% for all business loans, regardless of their credit quality. The Basel agreement paradoxically led, in some cases, to an increase in banks' risk taking, as opposed to its primary objective.

In order to overcome these shortcomings, the Basel Committee reached a new consensus in June 2004, actually called "revised arrangements" and no longer "new Basel agreement" as originally planned.

The central idea of Basel II is to allow banks to calculate their regulatory capital requirements for credit risk based on their internal risk data rather than by applying a flat-rate system. The **internal ratings approach** thus allows banks to calculate this regulatory requirement based on their own estimates of default probabilities (PD) and / or loss given default (LGD).

An intermediate approach, called the **standard approach** located mid-way between Basel I, for which it shares the fixed costs, and the Basel II IRB approach, for which it shares a greater sensitivity to risk by taking into account external ratings, is also provided for banks for smaller activities.

On the other hand, the methods for calculating regulatory capital requirements for market risk remain broadly unchanged, as the 1996 amendment has already introduced the possibility for banks to determine this requirement on the basis of internal models (VaR). Lastly, a new regulatory capital requirement is introduced to cover the operational risk faced by the bank.

All of these three minimum regulatory capital requirements, for credit, market and operational risk, constitute what is known as Basel II **Pillar 1**. The solvency ratio, renamed "McDonough Ratio", from the name of the Chairman of the Basel Committee from 1998 to 2000 (W.J. McDonough, President and CEO of the Federal Reserve Bank of New York), now reads as follows:

$$Solvency\ Ratio\ =\ \frac{Tier\ 1 + Tier\ 2 + Tier\ 3}{\sum (RWA_{CR} + RWA_{MR} + RWA_{OR})} \geq 8\% \tag{1.3}$$

To this first pillar are added :

- A second pillar or **pillar 2**, treating
  - The obligation of banks to assess their need for economic capital on the basis of

their risk profile extended to other types of risk than those taken into account by the pillar 1

  - The supervisory authorities' obligation to review the manner in which the banks perform this task

- A third pillar, or **pillar 3**, dealing with the obligation of banks to periodically publish a certain amount of information to the various market players.

1.2.3.1 Pillar 1 or minimum capital requirements

The first pillar of Basel II resumes, by **complementing** and **improving** it, the initial device which is basel I :

- On the one hand, it completes it, by adding a new type of risk : the **operational risk**

- On the other hand, it improves it by introducing the possibility of determining the capital requirement for **credit risk** on the basis of the **internal models** developed and used by the reporting institutions.

Pillar 1 therefore deals exclusively, as Basel I previously did, with the minimum capital requirements that a bank must satisfy : it sets out the set of rules whose application makes it possible to determine the solvency ratio of a legal entity subject to in Basel II.

Basel II Credit Risk Components

Probability of default (PD)

That of the Basel Committee, for companies, is as follows :
"A default is considered achieved in relation to a particular obligor when one of two events is found :

- The bank considers it unlikely that the debtor repays his debts in full to the banking group without resort to actions such as the realization of securities (if held).

- Delay of more than 90 days (past due) on any of its material obligations banking group.

An overdraft will be considered late when the debtor has exceeded the notified limit or has been notified of a lower limit than the current one".

Many banks have undertaken data collection efforts in recent years. But most do not have sufficient internal data for assigning loss characteristics of all borrowers from their own default history. These are still available for certain customer segments, particularly small or medium.
To estimate an average PD for each internal rating, banks may use statistical models to forecast default. Such models are based on historical databases losses that include the financial information of borrowers and identifying delinquent borrowers. The use of behavioral models could also ramp up. These default probability models use relations between a small number of independent variables and the probability of default.

Loss of default (LGD)

The probability of default is insufficient to assess the risks. The loss incurred in case of default or LGD (loss given default) is also important. It is equal to the amount of the debt less estimated recoveries after default.

$$\text{LGD} = 1 - \text{Recovery rate}$$

LGD assessment

In general, the factors used to evaluate the LGD are :

- Borrower characteristics: rating, country, size, industry sector, etc.
- The credit characteristics : subordinated or not, collateral value, realizable value of collateral, etc.
- Exogenous factors : economic cycle.

Exposure at default (EAD)

An important factor of the loss estimate is credit outstanding at default. it is referred to as outstanding, or exposure, when defaulting or exposure at default (EAD).
For balance sheet items, the amount is equal to the nominal amount outstanding at the calculation date.

Maturity (M)

Maturity is a major risk reduction factor. In case of risk deterioration, several options are possible if the maturity is short : do not renew the facilitates, reinforce the guarantees, increase rates,

etc.

The risk on a short-term debt is less important than a long-term debt on two borrowers of the same quality. But a long-term claim on a high-quality borrower is less risky than a short-term claim on a poor-quality borrower.

The chosen time horizon may be a year, the term of the loan or the business cycle. The time horizon is often a year because based on the cycle of the annual financial statements, the frequency of the internal review of the rating and the uncertainties of the projected performance beyond a year.

1.2.3.2 Pillar 2 or the prudential supervision process

The Basel Committee articulates Basel II around four main guiding principles :

- **Principle 1** : Banks should have a process for assessing their overall capital adequacy in relation to their risk profile and a strategy for maintaining their capital levels.
- **Principle 2** : Supervisors should review and evaluate banks' internal capital adequacy assessments and strategies, as well as their ability to monitor and ensure their compliance with regulatory capital ratios. Supervisors should take appropriate supervisory action if they are not satisfied with the result of this process.
- **Principle 3** : Supervisors should expect banks to operate above the minimum regulatory capital ratios and should have the ability to require banks to hold capital in excess of the minimum.
- **Principle 4** : Supervisors should seek to intervene at an early stage to prevent capital from falling below the minimum levels required to support the risk characteristics of a particular bank and should require rapid remedial action if capital is not maintained or restored.

These four main principles are actually articulated around two major poles, insofar as they emphasize the need :

- On the one hand, for the bank, to assess the adequacy of its equity in relation to all of its risks - which the CEBS summarizes as follows :
  Institutions should 'own', develop and manage the risk management processes; the ICAAP belongs to the institution and supervisors.

- On the other hand, for the supervisory authority, to review and assess this assessment made by the bank and undertake timely corrective action deemed necessary - which the CEBS summarizes as follows :
  The task of supervisory authority is to review and evaluate the ICAAP and the soundness of the internal governance process within which it is used.

1.2.3.3 Pillar 3 or market discipline

The third pillar (or pillar 3) of Basel II seeks to promote market discipline by formulating a set of requirements for the publication of information for the market. The communication of this information, which is of a quantitative as well as a qualitative nature, must enable the various market participants (financial analysts, investors, etc.) to assess in a transparent manner the main data relating to the risk profile of a bank and at its capitalization level.

1.2.4 Basel III, 2009

The financial crisis that began in the United States in 2007 and then spread to the entire planet revealed some weaknesses in the revised Basel II framework.

The crisis that began in 2007 was initially only a local crisis (United States) affecting a particular compartment of the US real estate market (the credit "**Subprime**"). But it has become global by the game of securitization of claims.

Subprime Crisis

The subprimes are mortgages granted from the 2000s to American households that do not meet the conditions to subscribe to a conventional mortgage. While traditional borrowers are called "prime", these modest households are called “subprime”. A new financial mechanism opens them access to credit : the loans they contract are pledged on the value of their property, which continues to climb. Some are even on the latent capital gains that these households could hope to achieve.

In the early 2000s, investors are fond of the financial securities generated by assembling these mortgages - so-called securitization. In a context of very low rates and abundant liquidity, they are looking for investments with higher returns. Supply and demand are in line to boost subprime growth.

The indebtedness of American households reaches its limits after a few years. Real estate prices flatten before collapsing : in mid-2006, they experienced their biggest fall for more than a century. Meanwhile, key rates rise, so that all the factors that contributed to the success of subprime have returned to encourage their fall. Many households can no longer honor monthly payments that were expected to increase over time, all the more so in some cases as the rates were variable. The real estate of a portion of insolvent households is seized, which maintains the fall in property prices. A hellish circle.

Banks suffer from their side of the depreciation of assets backed by these mortgages. From the summer of 2007, they spend quarterly in their accounts depreciations assets. Above all, the spread of subprimes via securitization has created a climate of distrust. Since no one knows exactly who holds what, banks stop trusting each other and lending themselves. It’s the liquidity crisis. In total, the IMF estimates that the subprime crisis will have cost the banks some $ 2200 billion.

Source : LE FIGARO

Some securitization practice has had a twofold effect on the management and perception of real risks :

- On the one hand, the banks and real estate brokers who initiated the loans to households were less vigilant about the ability of the latter to repay their loans, to the extent that they are paid commission and then resell the loan,

- On the other hand, investors located at the other end of the chain do not always have a clear view of the underlying risks to which they are exposed through **securitization** products, which can sometimes be securitization in the square. (securitization of a portfolio of assets that are themselves already the result of a securitization), cube, etc. In these cases, we speak of "re-securitization". therefore, they tended to rely exclusively on ratings from external agencies such as S & P, Moody's or Fitch.

Securitization

Securitization is a financial technique that transforms illiquid assets, that is, for which there is no real market such as credit, into easily tradable securities like bonds.

Source : La finance pour tous

Lastly, the rating agencies were criticized for not always demonstrating complete objectivity in their assessment of the credit quality of securitization products, since the same agencies themselves participated in return for payment to the structure. said operations.
It has thus been realized that a risk that an American bank or broker is bringing to American households is actually being carried by the securitization game by many investors around the world (bank, pensions, hedge funds, etc.), all investors ignoring most of the time the real risk they faced.
This global financial crisis has also been an opportunity to highlight other significant weaknesses of the new Basel II scheme, the most important of which are unquestionably :

- Its weakness in liquidity risk management (for example, the fall of Fortis on 26 September 2008 is due to a solvency problem, but to a liquidity crisis),
- Its procyclical effect on the economy.

Finally, it should be noted that the Basel II system has been transposed with some delay in some countries and that, moreover, it is not uniformly applied.
In the light of recent events, the Basel Committee published as early as July 2009 a set of documents designed to improve the pillars of Basel II (Enhancements to the Basel II framework) or to reinforce the 1996 rules on the trading portfolio (Revision to the Basel II market risk framework and guidelines for computing capital for incremental risk in trading book).
It is actually a whole program of reform that the committee has initiated, in order to draw the

prudential lessons of the financial crisis that begins in 2007 and to further frame the activity of banks. This reform, which was soon called Basel III, has several goals, the most important of which are listed below :

- Improve the quality of regulatory capital
- Increase the amount of regulatory capital
- Counter the procyclical effect of Basel II by encouraging the constitution in times of prosperity, a second protective mattress, or "countercyclical capital buffer" adding to the conservation wheel cited below - maintained at 0% in time normal but may increase to 2.5%.
- Strengthen equity requirements for counterparty risk on over-the-counter derivatives and repo and similar transactions.
- Limit the excessive lever effect to slow down unbridled growth.
- Introduce a liquidity standard. This risk, which caused the collapse of certain banking groups (including Fortis), was obviously underestimated before the crisis. It is now, therefore, very clearly the object of particular attention. The committee considers two types of constraints: on the one hand, a ratio measuring short-term liquidity needs (Liquidity Coverage Ratio), or a 30-day horizon; on the other hand, a ratio of stable funding available to the required stable funding (Net Stable Funding ratio).
- Encourage new rules of provisioning or depreciation. The committee has developed a proposal for the IASB to implement an accounting approach for provisioning based on expected losses and no longer only proven. This would spread the risk taking into account and smooth out the impact on the banks' result of the increase in insolvencies during a recession.

1.3 The national prudential regulations

1.3.1 National regulations

International regulations inspired the central bank to regulate as follows :

The circular 91-24 and 2012-09 relative to division, risk coverage and commitment follow-up where the circular 2012-09 is an updated version of the circular previously stated

First article is about the total risk incurred must not exceed :

- 3 times the net equity of the credit institution to beneficiaries whose risks amounted to each, 5% or more of said net equity
- 1.5 times the net equity of the credit institution, for beneficiaries whose risks amounted to each of them, 15% or more of said net equity

The **second article** of the same circular states that the risks on the same beneficiary must not exceed 25% of the credit institution net equity.
The **third article** is about the total risks on people with ties to the credit institution within the meaning of Article 23 of Law No. 2001-65 of 10 July 2001 relating to credit institutions, should not exceed once net equity of the credit institution.

The circular 2016-06 about Counterparts rating system

The purpose of this new circular is to enact a number of principles inspired by Basel framework's design; the structure; update, use and control of the scoring system. Article 25 of CBT Circular 2006-19.
Currently, the Tunisian prudential rules for hedging risks are largely inspired by the 1988 Basel I benchmark and its Cooke ratio. Only the credit risk is covered by a minimum level of equity in the provision of CBT Circular 91-24.
The new circular specifies that this should be a key role in the credit granting process, the pricing policy applied to customers, the risk management policy and the internal allocation of capital in the preparation of the Basel II agreement.

Rules to be respected for the internal rating system

Articles 4 to 10 of the new 2016-06 circular set out the rules and principles applicable for the definition of the rating parameters as well as the structure of the rating system. These rules are largely based on the minimum requirements for the Basel II Internal Rating Approach.
It should be noted that in order to be able to apply the Basel II Internal Ratings Approach, a

bank or financial institution must prove to its supervisory authority that it meets - and will continue to meet - the minimum requirements.
This scoring system must be characterized by two distinct parameters: the default risk of the borrower and the transaction specific factors.
It must include a counterparty rating scale that reflects only the quantification of their default risk. A minimum of seven categories for non-defaulting counterparts and one for default are required for this rating scale.
Institutions define the relationship between the categories (or ratings) of counterparts associated with a default risk level and the criteria used to determine that level. This should be used to calculate the Probability of Default (PD) estimates.
The circular also deals with the concentration of the credit portfolios of the institutions concerned as well as the requirements that the rating system must meet in these cases.
Article 5 of the circular requires written documents to specify the design of the rating systems and their operational modalities. The objective is that the definitions and criteria are sufficiently detailed, plausible and intuitive to allow counterparts with the same risk to be assigned the same rating.
This documentation of procedures required by Article 5 will also preserve the audit trail for any external audit.
In addition, the same Basel II requirements for rating parameters, time horizon for valuations and use of models have been included in the 2016-06 circular. Documentation relating to the scoring system The 2016-06 circular requires the institutions concerned to have appropriate documentation concerning :

- The design and operation of their rating systems
- The reasons and analysis that motivated the choice of rating criteria and that show that these criteria are able to provide ratings that significantly differentiate risks
- Any significant changes to the rating system
- The entire rating system, as well as the associated internal control
- The specific definitions of default and loss used by the institution

The same Basel rules and requirements for storing data and documentation in the case of using a model from a third party claiming that the technology used is its own, have been included in

that circular.

Governance and control of the rating system

The Board of Directors of the bank or financial institution is responsible, in accordance with the provisions of **Article 13** of the circular, for the validation of the rating system.
The circular requires members of the board of directors and the management body to have a good knowledge of the rating system put in place.
Articles 14 and 15 of the Circular add that the institution's credit risk management structure is responsible for the design or selection of the rating system, its implementation, its oversight and its effectiveness. and that the internal auditing structure is required to review, at least once a year, the rating system and its operation, and to ensure compliance with the minimum requirements set out in this circular.
This review by the internal audit structure must lead to the drafting of a report that must be sent to the Central Bank of Tunisia no later than one month after its validation by the Board of Directors.

1.3.2 Assets' classification and the constitution of provisions

According to **Article 8** of the circular 91-24, banks are required to classify their assets regardless of their form (on or off the balance sheet, in dinars or foreign currencies). The latter will therefore be classified as current assets and classified assets. Assets held on the CBT or on the State are not the subject of this classification.

- **Current Assets** These are assets whose full recovery in time seems assured and which are held on companies whose financial situation is balanced.
- **Classified Assets** These are assets whose repayment is uncertain. The risk materializes in a risk of unpaid debt whose degree of seriousness is classified into four classes :
  - **Class 1 : Assets requiring special monitoring** These assets have an outstanding amount of < 90 days, which is fully recovered in time, but held on companies with a business sector experiencing difficulties or having a deteriorating financial situation.
  - **Class 2 : Uncertain Assets** It is the assets whose unpaid amount covers a period from 90 to 180 days and the full recovery on time is uncertain. They are generally

held on companies that are in financial difficulty.

The provisions to be constituted are at least 20% for the assets of this class.

- **Class 3 : Preoccupying assets** This class is concerned with assets held by companies with a late payment of more than 180 days without exceeding 365 days. Banks must make provisions of at least 50% for assets belonging to this class.
- **Class 4 : Compromised assets** This class is concerned with assets held by companies with a late payment of more than 365 days. All receivables relating to these assets requiring full funding (100%).

It should be noted that the provisions must be allocated specifically to any asset classed ≥ 50000 dinars and this taking into account the guarantees received by the State, insurance, credit institutions as well as guarantees in the form of deposits. or financial assets that may be liquidated without affecting their value.

Conclusion

Chapter 2

Credit risk measurement

Introduction

2.1 Credit risk main components

Credit risk models can be listed in different ways, here are the different categories that can be found in literature. The literature has several possible measures for determining credit risk. In this section the focus is on the usual measures of credit risk since they are essential for understanding the development of this dissertation.

2.1.1 Default

In order to be able to conduct any study on credit risk, one must define the notion of default. Being a complex notion, there are different definitions of default specific to each financial institution whether regulator, rating agency or bank.

According to the Basel Committee, an obligor is considered to be in default when the latter reaches 90 days with unpaid debts.

In the tunisian context, with respect to the classification process, used to adopt a different definition of default; a borrower is considered in default when he reaches the 4^{th} class of risk with 365 days with unpaid debts. Nevertheless, the banks of the place tend to adopt to the Basel committee definition in order to prepare for upcoming environment transformations.

In this dissertation, it is important to note that the basel committee definition is taken into account aiming to prepare for future changes.

2.1.2 Expected loss (EL)

Statistically speaking, expected loss or average loss, represents the average amount that a lender institution may lose on its credit portfolio over a given horizon. Compute this measure is function to the determination of three parameters; the probability of default (PD), the exposure at default (EAD) referring to the amount of capital remaining due or exposure and loss given the event of default (LGD), which is function of the recovery rate. The relationship can be described by the following equation :

$$\text{EL} = \text{PD} \times \text{EAD} \times \text{LGD} \tag{2.1}$$

These parameters represents the main transformations made by Basel II's first pillar for the overhaul of credit risk (see section 1.2.3.1). As a result of determining the average losses, one can be able to reach the next step which is the constitution of the provisions. Nevertheless, the amount of actual losses may as well differ from those due to uncertainty.

2.1.3 Value at risk (VaR)

Value at Risk, commonly called Value-at-Risk, is a measure that aims to summarize in a single number the expected maximum loss or the worst expected loss on a portfolio of financial assets, with a confidence level and a given time horizon (usually one year). Initially applied to market risks. As mentioned above, VaR depends on two elements :

- *The time horizon T* commonly known as the holding period "holding period", corresponds to the period over which the change in portfolio value test is measured. Note that the more the horizon extends, the more the losses can be significant.

- *The confidence level* α that corresponds to the probability of not exceeding the VaR. In practice, the confidence level is set by the regulatory authorities to 99%, in other words the probability that the realized loss is greater than the maximum loss during the period was 1%.

The calculation of VaR allows us to answer the question "how much the value of a portfolio can it deteriorate?"
Statistically speaking, the VaR confidence level α is the order of the quantile of the loss distribution, with a time horizon given. Let's suppose that X is a random variable representing the

potential loss on a financial asset portfolio, and F its distribution function with the following representation :

$$VaR_{1-\alpha}(X) = \inf_{t\in\mathbb{R}}\{t : P(X \leq t) \geq 1 - \alpha\} \tag{2.2}$$

We can be certain that with $\alpha\%$ chance, we will not lose more "VaR" dinars on our holding period. VaR can be calculated using a loss distribution, or the gain is a negative loss. The following figure shows an illustration of the VaR on a typical credit loss distribution :

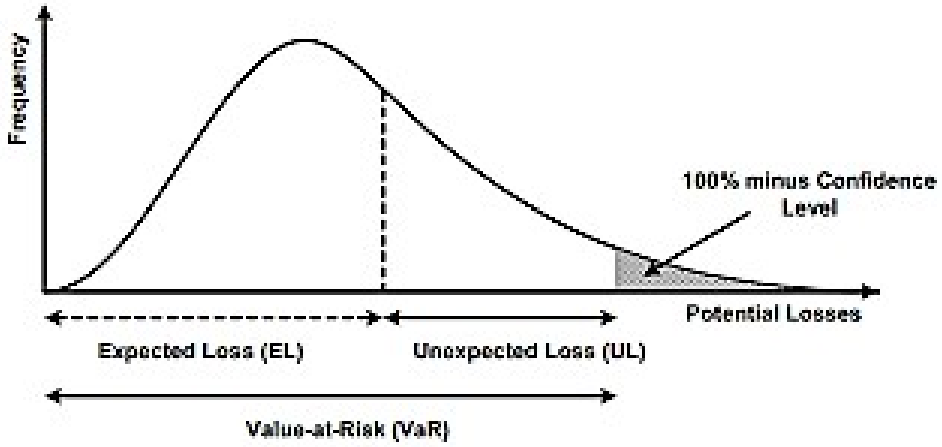

Figure 2.1 – Illustration of the potential loss distribution

The VaR has many advantages, it is a synthesizing measure for assessing the maximum risk of a portfolio. The availability of a synthetic indicator also allows us to make a comparison between several portfolio. Then, it has the benefit of being easy to test ex-post[1].

The main limitation of VaR is that it gives no indication concerning the importance or the amount of loss in the "$1 - \alpha$" riskier cases.

2.1.4 Unexpected loss (UL)

As the average losses, unexpected losses are a concern for the bank. They depend on maximum losses and expected losses. The relationship can be formulated as follows :

$$\text{UL} = \text{VaR} - \text{EL} \tag{2.3}$$

Where the VaR represents the valur at risk which is no other than the maximum loss at a certain confidence level of $\alpha\%$, mostly it is fixed to 1% for caution purposes.

Despite a low probability of occurrence, unexpected losses represent a serious risk, which can induce the lender institution bankrupt.

[1] An ex-post study is a study after a specific action and usually aims to measure the effects of this same action.

2.1.5 Economic capital (EC)

Economic capital represents the amount of capital that an institution must allocate to hedge unexpected losses. Its main advantage is that it is a more appropriate and comprehensive measure of risk than that provided by the Basel Committee.

Its main advantage consists of the fact that it is a more appropriate and comprehensive measure of risk than that provided by the Basel Committee. Indeed, the unexpected risk taken into account by the internal models for calculating economic capital is more comprehensive than the risk involved in the regulation.

In addition, hedging against unexpected losses does not necessarily require an increase in the economic capital. For example, managerial quality can be used as a hedge against unexpected losses in the determination of economic capital.

Another advantage of economic capital assets is that it takes into account the correlations between microeconomic risks and macroeconomic risks that could affect the debtor's financial strength. Thus, the geographical situation, the sector of activity of the counterparts as well as the evolution of the general economic situation are all information incorporated in the risk measurement as to better appreciate the potential failures of the counterparts.

Economic capital is also an essential tool for strategic management within a bank, in addition to identifying the most profitable activities and thus optimally managing capital allocations. Thus unlike the regulatory capital that aims to ensure a certain banking solidity, economic capital meanwhile has a different vision by conditioning risk taking with the objective of maximizing returns activities.

Finally, a financial institution may set a rating target. From then, it must respect a certain amount of economic capital to cover unexpected losses such that its probability of default splint horizon of one year does not exceed a certain percentage. The more the financial institution is downgraded to the risk of insolvency, the higher the level of confidence and the higher the amount of economic capital required, which may even exceed the amount of regulatory capital. As mentioned previously, the risk measures dependant on confidence level as for the Value at Risk and the economic capital generated capital amount differs depending on the determined confidence level. However, the unsolved is about the effect of confidence level on the amount of capital allocation.

The contribution to risk "RC"

As mentioned above, under the influence of the diversification effect, the portfolio unexpected loss is less than the sum of the unexpected losses on each counterpart for the same portfolio :

$$\mathrm{UL}_i \geq \sum_{i=1}^{n} \mathrm{UL}_i$$

This implies that only a fraction of unexpected losses on individual exposures actually contributed to portfolio risk. From a mathematical point of view, the contribution to the portfolio risk exposure of i is given by the following formula :

$$\mathrm{RC}_i = \mathrm{UL}_i \frac{d\,\mathrm{UL}_p}{d\,\mathrm{UL}_i} \tag{2.4}$$

Or, taking account of default correlations :

$$\mathrm{RC}_i = \mathrm{UL}_i \sum_j \frac{\mathrm{UL}_j\,\rho_{ij}}{\mathrm{UL}_p} \tag{2.5}$$

where

$$\mathrm{UL}_p = \sum_i \mathrm{RC_i}$$

It is important to be interested in this contribution because it allows us to quantify the contribution of a counterparty or an obligor to the whole portfolio risk, furthermore, it allows us to measure the contribution of each individual exposure to the bank's economic capital.
It is also a measure of sensitivity towards the unexpected loss of the portfolio compared with the unexpected loss of exposure. Moreover the risk contribution allows us to quantify the amount of the non-diversifiable credit risk of an individual exposure within the portfolio.

2.1.6 Expected shortfall (ES)

The expected shortfall refers to the average of losses greater than VaR which is the maximum potential loss to the extent of a certain confidence level percentage α.

$$ES_\alpha = \mathbb{E}(X|X \leq VaR(X, \alpha)) \tag{2.6}$$

This is the conditional expectation of losses considering the VaR level.

2.2 Individual credit risk measures

The individual measures of credit risk vary between internal measures designed by the lending institution and other external developed by the rating agencies. The first category concerns score models or expert systems while the second category focuses on rating systems.
With the help of the Basel II regulatory framework, internal measures have gradually been refined in the sense that banks are trying to reproduce more closely the quantitative and qualitative tools developed by the rating agencies. The rating of a company, whether external or internal, allows lenders to better assess the issuers' solvency.

Rating issuers

A rating system or rating or rank, is a synthetic indicator, as a note, which assesses the credit risk of a loan or borrower. The rating also expresses, in a more advanced approach, other risk factors such as the probability of default, loss given default, probability of transition from a favorable rating to an unfavorable one. It can be based on the characteristics of the single borrower, on the characteristics of single loan or on joint characteristics of the borrower and the loan.

Standard Approach

The Basel II standard approach represents a transition from Basel I to the internal rating approach.
Compared to **Basel I** : the standard approach of Basel II essentially provides greater sensitivity to risk due to the inclusion of external ratings assigned by rating agencies such as S&P, Moody's or Fitch, to name the three largest globally.
This greater sensitivity to risk, however, *has no impact on the weighting of retail exposures, which are not rated by definition, and that there is little impact on exposure weighting for small and medium-sized (SMEs) rarely noted in practice*.
Compared to **Basel II**'s **IRB** approach : the Basel II standard approach remains based on risk assessment criteria that are external to the reporting institution: the weightings applied are entirely dependent on the ratings awarded by rating agencies, and the economic capital calculated by the institution on the basis of its own internal models, remains large.

2.2.1 External rating

Several external rating sources are available :

- Rating agencies (eg Moody's, Fitch, S&P)
- Public data banks (central credit registers) as that of the Bank of France (Fiben);
- Insurance Agencies of export credits for sovereign risks, such as Coface in France or insurance agency loans.

To rate, two approaches are possible.

- The rating is assigned to a borrower. It then applies to all debts called "seniors": system called "one-dimensional".
- The borrower receives an overall score and a score for each facility. This last note combines the borrower's note and the characteristics of the facility (guarantees, rank, specific clauses, etc.). This system is called "two-dimensional".

In fact, these two approaches have complementary uses. To calculate the probability of default (PD) only the borrower should be considered. It will fail or not whatever the characteristics of the facilities it enjoys. However, to assess the recovery rate given default (loss given default or LGD), the characteristics of the facility must be considered. It is obvious that the guarantees attached to the ease (or senior subordinated, secured or not) will significantly influence the LGD.

Horizon of one year or over an economic cycle

The time horizon may be a year, the term of the loan or the business cycle. An appreciation over one year provides a good visibility and scoring resulting takes this into account. An assessment of an entire economic cycle called "through the cycle" (seven to ten years) will assess the behavior of the borrower at the bottom of the economic cycle. Visibility is much worse but the scoring ensuing be much more cautious.

Economic role of rating agencies

Before granting a loan, a bank has the means and the duty to conduct a comprehensive study on the creditworthiness of the potential borrower and decide whether to grant credit.

A bank has an interest in preserving the confidentiality of its analyzes in order to avoid that the competition profits by making the economy of this expensive work. But investors, individuals and investors are far from having the means of investigation of banks. It is the role of rating agencies to conduct such a study, the results can be shared by all potential subscribers.
A rating agency publishes its ratings and charged the cost of the work to the issuer or its paying subscribers.

Rating of issuers

The notes typically use the letters AAA, AA, A, BBB, etc. A note attributed to an issuer is a review of its overall capacity to meet its financial commitments. It does not take into account the specifics of a debt (guarantees, particular clauses, rank, maturity, etc.).
The table below shows the symbols and definitions used by the two major rating agencies Standard & Poor's and Moody's. Their system is comparable and reconcilable. Another major rating agency, Fitch IBCA, uses the same grid as Standard & Poor's.
Standard & Poor's emphasizes the borrower's ability to meet its financial commitments and Moody's focuses its financial position. The notes from AA are refined by the addition of a + or - (S & P) or the number 1, 2 or 3 (Moody's) to introduce within the same note a hierarchy. From BB (S&P) and Ba (Moody's) the notes are considered "speculative" While the previous ones are considered "investment".

Table 2.1 – Meaning of external ratings

S&P	Moody's	Interpretation
AAA	Aaa	**S&P** - Extremely strong ability to meet financial commitments. **Moody's** - Outstanding Financial Security. Even in the event of changes in the financial situation, its position will remain fundamentally strong.
AA	Aa	**S&P** - Strong ability to meet financial commitments. It differs slightly from the previous notation. **Moody's** - Excellent financial security. It is less well rated than Aaa because the long-term risk appears higher. These two notes are high-grade issuers.
A	A	**S&P** - Strong ability to meet financial commitments. More likely to be affected by changing circumstances and economic conditions than previous ratings. **Moody's** - Good financial security. Current elements may suggest a possibility of degradation in the future.
BBB	Baa	**S&P** - Adequate ability to meet financial commitments. Adverse changes in circumstances or economic conditions are likely to weaken its ability to meet its financial commitments. **Moody's** - adequate financial security. But some protective elements may be missing or uncertain for a long time.
BB to C	Ba to C	**S&P** - Large uncertainties and risks in the face of poor economic and financial conditions can lead to an inadequate ability to meet financial commitments. Less vulnerable in the short term than lower ratings. **Moody's** - uncertain financial security. Often the ability of this issuer to meet its financial commitments is moderate and uncertain in the future.
BB	Ba	**S&P** - Ability to meet financial commitments in the short term. Unfavorable business, financial or economic conditions are likely to deteriorate its ability or willingness to meet its financial commitments. **Moody's** - poor financial security. The assurance of compliance with its financial commitments over a long period is low.
B	B	**S&P** - Currently vulnerable. Its ability to meet its financial commitments depends on favorable business, financial and economic conditions. **Moody's** - very poor financial security. They may be in default or risk elements present may prevent compliance with the scheduled repayments.
CCC	Caa	**S&P** - Currently highly vulnerable. **Moody's** - Extremely poor financial security. Often in default or significant weaknesses.
C	C	**S&P** - Highly vulnerable to the cessation of payment. **Moody's** - Usually in default and low recovery potential.
D		**S & P** - In default on one or more of its financial obligations.

2.2.2 Internal rating

We have seen that the **weightings** were, both in Basel I and in the Basel II standard approach, set once and for all by regulation : the same discrete values (eg 20%, 50%, 100%) are applied by all establishments. These values are always rational numbers : *they are indeed not the result of a formula, but a* **convention**. In the **IRB approach**, however, the weights are no longer set by the regulations : **continuous** values (eg. 1.156361%, 1.571984%, 1.922497%) different applied there by each institution. These values are often irrational numbers: they are indeed not the result of a convention, but a formula - also called "function K". (i.e. function determining the capital charge, abbrev. K).

If the formula applied is imposed by the regulations, and is the same for all institutions subject to Basel II throughout the world, the value of its key parameters is, however, determined by the institution itself based on its own internal models.

As these internal models, as well as historical on which they are based, differ from one institution to another, the values returned by the formula (K, capital charge, expressed as a percentage of the value of exposures or EAD) also differ from one institution to another.

2.2.2.1 IRB approaches

Basic IRB approach

In its basic version, the “foundation internal ratings-Based approach”, abbreviated *FIRBA*, the institution must determine the value of the probability of default’s value (**PD**) **based on its internal models**. However, the value of the loss in case of default (**LGD**) is **fixed by the regulations**.

The value of the effective maturity (**M**) is, in the basic approach, **determined by regulations**, though, there is a national discretion allowing the supervisory authority to ask the institutions applying the basic approach to calculate the value of M in advanced approach.

Finally, the conversion factor (**CCF**) determining the risk-exposure value (**EAD**), and therefore the risk-weighted assets (**RWA**), of off-balance sheet exposures is also **determined by the regulations**.

Advanced IRB approach

In its advanced version, called "advanced approach based on internal ratings", abbreviated *AIRBA*, the institution must determine, **both** the value of the probability of default (**PD**) and that of the loss in case of default (**LGD**), based on its internal models.
The value of the actual maturity (**M**) is, in the advanced approach, **calculated by the institution**, but there is a national discretion allowing the supervisory authority to ask the institutions applying the advanced IRB approach to apply the regulatory value of M in the basic approach.
Finally, the conversion factor (**CCF**) determining the risk-exposure value (**EAD**), and therefore the risk-weighted assets (**RWA**), of off-balance sheet exposures is also **determined by the institution** on the basis of its own internal model.

Table 2.2 – FIRB vs AIRB

Basic IRB or Foundation IRB		**Advanced IRB**	
PD	Internal model	**PD**	Internal model
LGD	Fixed by regulations	**LGD**	Internal model
M	Fixed by regulations	**M**	Internal model
CCF/EAD/RWA	Fixed by regulations	**CCF/EAD/RWA**	Internal model

2.2.2.2 Expert systems and scoring

Banks use expert systems and model scoring in order to decide whether to grant credit, as well as, to rate borrowers. Despite their common goal, they each present a different approach in the sense that expert systems are based on qualitative methods whereas score models are based on quantitative ones.

Expert systems

Expert systems define a regulatory framework for credit risk measurement from the rules of experts. They use qualitative accounting and financial information to assess the risk of companies.
These are, on the one hand, borrowers' financial characteristics (financial structure, financial strength, debt status, level of collateral, etc.), and on the other hand, market information and the competitive position of the company (position of products on the market, state of technology

and productive performance in relation to the sector, perspective of evolution of supply and demand, leading position or not).

It should be noted however that the rating agencies Standard & Poor's and Moody's assign a weight to the second type of information in risk analysis. Nevertheless, a subjectivity characterizes the expert systems insofar as they rely on the experience of the experts. For example, the quality of management of a leader can be appreciated in a heterogeneous way by different experts. Moreover, it remains difficult to define scientific procedures for testing the results obtained.

Scoring models

Scoring models use historical data and statistical techniques to measure credit risk when making the commitment decision. They produce scores or ratings to assess the default risk of actual or potential borrowers.

Building a scoring model requires two populations of borrowers. The first class includes defaulting borrowers and the second includes non-defaulting borrowers. The implementation of the model has four stages.

1. *The choice of failure criteria and the constitution of the populations analyzed*

   The choice of failure criteria can range from a simple late payment to the legal borrower defaults. To build a scoring model, it is recommended to have historical data for a sufficient number of healthy borrowers and other default. The sample made from homogeneous bank customers, must be representative of the population of borrowers in default.

2. *The choice of explanatory variables*

   The idea is to determine the economic and financial characteristics that can distinguish between healthy and failing borrowers. The data used in accounting and financial (financial ratios) or bank (operation of the bank or debt situation) or qualitative (professional category, age, geographic location), especially in the scoring of consumer credit granted to individual customers.

   A primary condition for the use of risk factors identified : they must be independent.

3. *The choice of statistical techniques*

   Statistical techniques prevalent in banking are econometric techniques (logit and probit models) and classification techniques after data analysis (linear discriminate the model).

4. *Assessment methods*

   The evaluation of scoring models is by the use of tools from statistical inference and compliance signs of the coefficients of the model with the principles of financial analysis. Furthermore, the object of the scoring model is to classify borrowers into two distinct categories - default and no default. For any borrower, the score function is given by a linear combination of the explanatory variables (ratios, for example).

$$Z_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + ... + +\beta_n X_{ni}$$

   Successful borrowers are awarded high scores, reflecting a low default risk, while bad borrowers score low. A scoring model is considered good if it admits a good ranking rate by class of population or the total population high, close to 90%.

   Scoring models are statistical tools suitable for the mass processing of large portfolios. Nevertheless, they include errors of the kind to be considered in default of healthy borrowers or to classify as healthy defaulting borrowers.

2.3 Portfolio credit risk models

Structural models (SM) or default intensity models (DIM)

Structural models are grounded in the development proposed by Merton (1974) which is based on technical assessments options developed by Black and Scholes (1937). The latter dictates that the failure of a firm is involved when the value of its assets is no longer sufficient to repay its debts at maturity. This type of model is called structural because it directly links the credit risk to the financial structure of the firm. Highly developed by the financial industry since the second half of the 1990s, the main structural models used are the JP Morgan CreditMetrics model and the Moody's KMV Portfolio Manager model.

Default Intensity models do not condition the default event to the financial structure of the enterprise. It is therefore not necessary to estimate the parameters of the asset value distribution, as well as the volatility of these assets. These models assume that the defect is unpredictable and is defined as a stochastic process called fault intensity. The best-known default current model is probably the CreditRisk$^+$ model.

2.3.1 Moody's KMV : portfolio manager

This model is based on Merton's reasoning. In this case too a fault occurs whenever the value of assets of a firm becomes less than its debts. In the case of the MKMV model, an important notion is introduced that is EDF's (Expected Default Frequency), the latter differs from the probabilities of default inferred by rating categories, it represents the PD estimate derived from a Merton type model.
The estimate of the EDFs goes through 3 main stages :

Stage 1 - The estimate of the market value and volatility of the assets of a firm

The KMV model is based on the assumption that the value of assets follows a log-normal distribution[2]. Furthermore it is assumed that its volatitlity is stable over time.
If the liabilities of any company is rated on a mark-to-market approach (the value of liabilities is known from day to day according to its market price) estimating the market value and the volatility of the rendering of its assets would be easy. The asset market value of the company would be equal to the sum of the market values of its liability items, and the volatility would be obtained through the time series data of the estimated values of assets.

In practice, however, only the value of equity is observable in the market and only a few items of liabilities are exchanged. KMV's alternative approach (derived from Merton's development) for valuing assets is to apply Black & Scholes option pricing techniques to estimate the value of liabilities. The KMV model also assumes that the capital structure of any firm is composed solely of equity, highly liquid short-term debt, long-term debt assumed to have no maturity, and preferred shares convertible into common shares. Thus, through these different assumptions can be evaluated analytically the value of equity E and its volatility "σ_E". A security that combines the characteristics of common and fixed-income debt.

Stage 2 - Measure the distance to default

The Portfolio Manager model distinguishes between default and bankruptcy, in fact bankruptcy is presented as the position or the company is in liquidation and that the proceeds of such

[2] $\log(A) \rightsquigarrow$ Normal distribution

liquidation is paid to the creditor in accordance with their priority orders. The default occurs when a firm does not honor a payment of interest and / or principal at a specified maturity of the debt.

The MKMV introduced an intermediate step before calculating PDs, it measures the "default distance (DD)" which represents the distance between the expected value of the company's assets and a critical threshold called "the default point (DPT)" defined as the value of current liabilities to which we add half of long-term debt. This methodology's was motivated by the research conducted by KMV over a sample, leading to the conclusion that a firm fails when the value of its assets to a level between the total value of its liabilities and the value of its short-term debt.

The default point is given by : $DPT = STD + 1/2\ LTD$.

And therefore distance to default (DD), representing the distance between the expected value of the asset over the horizon of a year $E(A_t)$ and the default point expressed with respect to the volatility of the rendering of the asset is given by :

$$DD = \frac{E(A_t) - DPT}{\sigma_A}$$

The following figure shows the mechanism of the development described above :

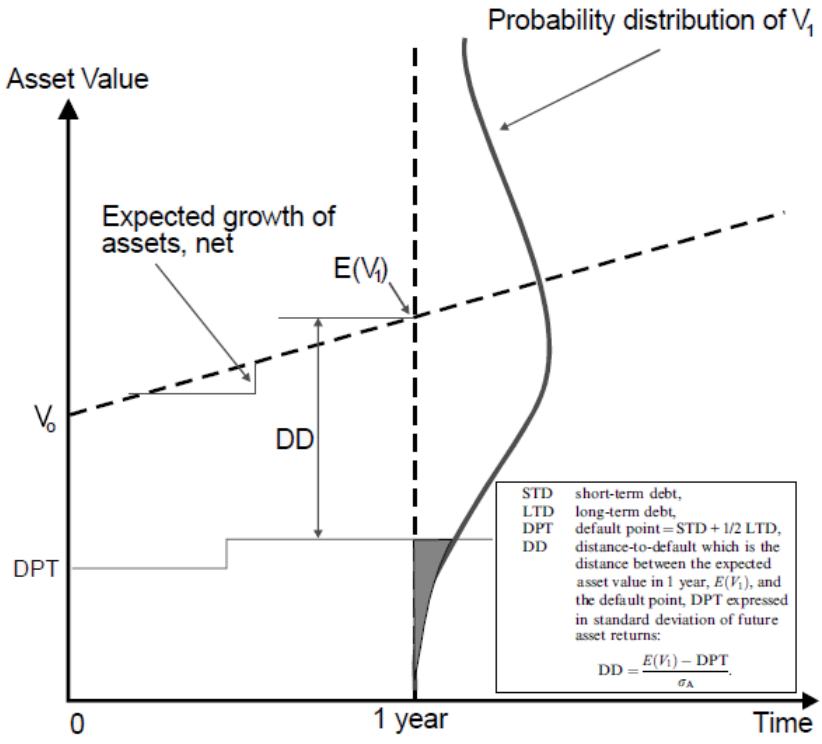

Figure 2.2 – Distribution of the firms' assets value at maturity of the debt obligation

Source : Crouchy et al.(2000)

Moreover, given that At is distributed according to a log-normal distribution and by adopting the analysis provided by Black & Scholes, DD can be expressed as follows :

$$DD = \frac{\ln\left(\frac{V_0}{DPT_T}\right) + \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

Where

- V_0 : the market value of the assets
- DPT_T : the default point to the T horizon
- μ : the expected net value of the assets
- σ : its annual volatility

Stage 3 - Determination of default probabilities from the Distance to Default

This last phase is to match the different values of DD to EDF's. Using historical data on a large sample of companies, we manage to estimate for each time horizon the proportion for a given value of DD, which failed after 1 year.

2.3.2 JP Morgan's CreditMetrics

2.3.3 Credit Suisse's CreditRisk$^+$

The CreditRisk$^+$ model uses an analytical approach to determine losses associated with a portfolio of bonds or bank loans. He is interested only in fault events. It does not take into account the credit risk arising from the depreciation of the quality of debtors.
Unlike the KMV-Moody's PortofolioManager model, the default event is not related to the capital structure of the company. The CreditRisk$^+$ model offers no explanation as to the occurrence of the default event. It is considered, then, as an intensity model.
The assumptions underlying the model state that, for a commitment portfolio, the probability of default of an individual transaction is low and that the number of defaults, noted for a given period, is independent of the default number of the other periods.

Supported by these assumptions, the probability distribution of the number n of defects is represented by a Poisson distribution :

$$P(n \text{ defaults}) = \frac{\mu^n e^{-\mu}}{n!} \text{ avec } n = 1, 2, 3, ..$$

where μ represents the average number of defects incurred during a given duration.
In order to derive the distribution of losses from a portfolio of liabilities, the losses, equal to the outstanding credits net of the amount recovered, are divided into bands and then grouped by equal exposure bands.

Table 2.3 – Determination of credit risk exposures

Obligor A	Exposure ($) (Loss Given Default)	Exposure in bands	Round-off exposure (in $100000)	Band j
O_A	L_A	$\bar{v}_j$	v_j	B_j
1	150 000	1.5	2	2
2	460 000	4.6	5	5
3	435 000	4.35	5	5
4	370 000	3.7	4	4
5	190 000	1.9	2	2
6	480 000	4.8	5	5

Source : Crouhy et al. (2000)

It is relevant to be aware of the CreditRisk$^+$ definition of exposure, which is amount of loss given the event of default :

$$\text{Amount Loss Given Default} = \text{EAD} \times \text{LGD (\%)} \tag{2.7}$$

Each band is considered a portfolio of bank loans or bonds, independently of other bands. Each band j is characterized by :

$$\varepsilon_j = \mu_j \, v_j \quad \Leftrightarrow \quad \mu_j = \frac{\varepsilon_j}{v_j} \tag{2.8}$$

where v_j represents the exposure expressed in multiples of a standard exposure L at the j band ε_j means the average expected loss in multiples of L and μ_j is the number of expected defects.
Thus, the loss distribution of a portfolio is determined in three steps :

Step 1 : The probability generating function of each band

The probability generating function of each band j is defined as follows :

$$G_j(z) = \sum_{n=0}^{\infty} P(\text{Loss} = nL)\, z^n = \sum_{n=0}^{\infty} P(\ n \text{ defaults }\ )\, z^{n.v_j} \tag{2.9}$$

Since the number of defaults follows a Poisson distribution, the equation 2.9 becomes :

$$G_j(z) = \sum_{n=0}^{\infty} \frac{\exp\left(-\mu_j\right)\mu_j^n}{n!}\, z^{n.v_j} = \exp\left(-\mu_j + \mu_j.z^{v_j}\right) \tag{2.10}$$

Step 2 : The probability generating function of the entire portfolio

The probability generating function of an entire portfolio is as follows :

$$G(z) = \prod_{j=1}^{m} \exp\left(-\mu_j + \mu_j.z^{v_j}\right) = \exp\left(-\sum_{j=1}^{m} \mu_j + \sum_{j=1}^{m} \mu_j z^{v_j}\right) \tag{2.11}$$

Step 3 : The distribution of losses for the entire portfolio

The loss probability distribution function for an entire portfolio is given by the following equation :

$$P(\text{Loss} = nL) = \frac{1}{n!}\frac{d^n G(z)}{dz^n} \tag{2.12}$$

The CreditRisk$^+$ model, characterized by a single period and a single factor may undergo several extensions. First, it can be extended to a multi-period approach. Then, the volatility of the default rates can be linked by a multifactorial analysis in which the default factors are expressed according to the countries or sectors of activity.

In the end, the model CreditRisk$^+$ is only interested in the event of default. It can be set up easily, requiring the estimation of some parameters. More specifically, for each counterparty, only the probability of default and exposure are essential. The model differs from CreditMetrics model by taking into account explicitly the volatility of default rates. Besides, Gordy (2000) shows that it is possible to switch from one model to another with some algebraic and statistical manipulations.

Nevertheless, the CreditRisk$^+$ model has some failures. In respect of the models Portofolio Manager KMV Moody's, CreditRisk$^+$ model ignores migration-related effects. The changes in the quality of borrowers are not taken into account, which leads to an underestimation of the credit risk of a portfolio.

Conclusion

Part II

Empirical part

Chapter 3

Empirical input and background

Introduction

3.1 Presentation of the sponsorship bank

A pioneer in the development of the country, the STB was established in 1957, a year before the establishment of the Central Bank of Tunisia. This is the first specifically designed Tunisian bank to effectively contribute to economic and social development of Tunisia. It has a registered capital of 776,875.000 million Tunisian dinars.

Besides its creation by a share capital of 10,000 dinars, the state participation is 52%, the equity of the STB has evolved at a steady pace by fourteen capital increases.

Until the mid-1970s, it emerged on the credit market as a multi-purpose deposit, business and development bank at the same time. Indeed, she has been the initiator of the largest projects in the sectors of industry, tourism, agriculture and trade. By working on the national interest, STB has gone beyond its role as a banker and has grown for more than thirty years as one of the largest banks in terms of performance. As part of the restructuring plan and modernization of the banking sector, in the late 90s, STB performed a thorough restructuring.

In 2000, the STB was facing a difficult task of absorption of both development banks the Economic Development Bank of Tunisia (BDET) and National Bank for Tourism Development (BNDT) to save the country's image after bankruptcy. For this, the bank found itself with a new structure, supporting the debts of the two development banks. However, with greater efficiency and a significant synergy of resources and skills, it has continued to rank among the leading banks in the Maghreb and the African continent. To illustrate, the STB has always been the

first bank in terms of deposits, credit. Also, it has been and will always be at the service of the Tunisian economy.

In 2013, in order to take control, the bank began a full audit, which lasted two years. Following which a restructuring report was elaborated.

In 2015, following the demands of the IMF and pursuant to second article of the 21 August 2015 law on strengthening the financial soundness of STB and BH, the bank carried out a capital increase in the amount of 652,575,000 TND.

STB then set a 2016-2020 strategy to address the gaps. Among the reforms are : the establishment of a 100% Tunisian Global Banking, with the collaboration of the BFI group, the acquisition of a new electronic payment solution, the digital transformation, development of the agency network, the strengthening of the internal control system and the establishment of an internal rating system to improve the quality of the bank's assets, the rejuvenation of staff, following the latest recruitment in 2016 and 2018, the implementation of a retirement plan, etc.

3.2 The sample's analysis

The SME sample, which credit risk is going to be assessed in this paper, is composed of 1144 SMEs from different sectors and belonging to various rating classes. In the sections below, the sample is described according to two criteria :

- **Rating classes**

  The classes reflect the SME's solvency and tendency to fall in default. The rating classes are organized by risk degree where :

  AAA : Excellent solvency state

  AA : Very good solvency state

  A : Good solvency state

  BBB : Moderated credit risk

  BB : Acceptable credit risk

  B : High credit risk

  C : Very high credit risk

  This rating system notation is set with reference to the one set by S&P.

  As you can see in figure 3.1, where the figures refer to the frequencies per rating. The

sample is mainly composed of AAA counterparts at the level of 27.19%. The classes AAA, AA and A represent 74.22% of the sample where the BBB class owns 15.12% and the BB, B and C classes have respectively 4.11%, 2.53% and 4.02%.

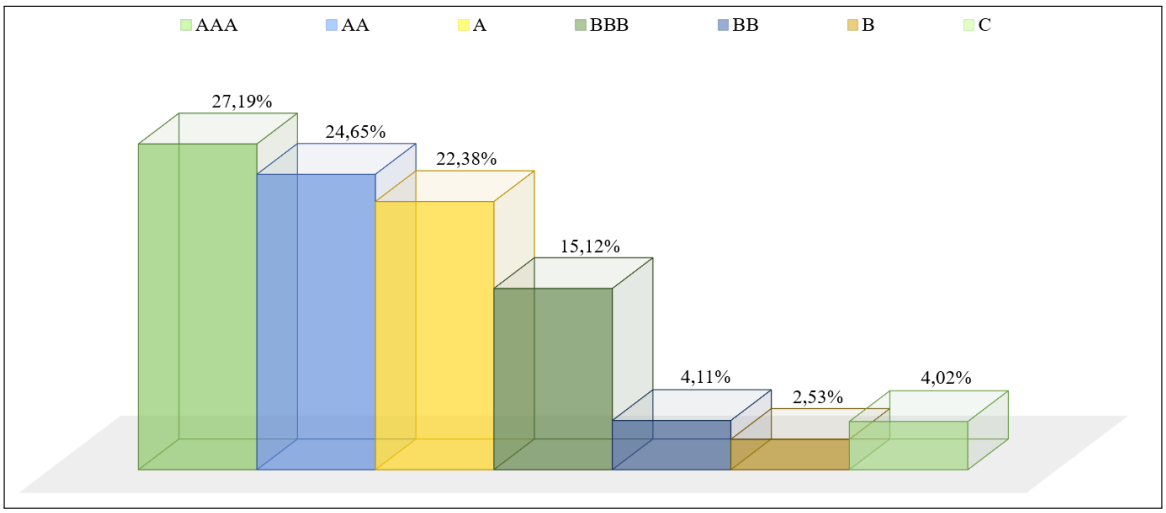

Figure 3.1 – Frequencies per rating

In the latter, analysis will be displayed showing the average PD per rating (Fig 3.3). From figure 3.3 and figure 3.1, we remark that 71.22% of the sample have an average propensity to fall into default of almost 0%.

- **Sector of activity**

  We denote eight sectors of activity among our sample which are

  - Agriculture
  - Other Industries
  - Other Services
  - Building & Public Works
  - Trade
  - Manufacturing Industries
  - Real Estate Promotions
  - Tourism

  The figure show that 35.31% of the SMEs belong to the Trade sector, the manufacturing industries with 25.44% and the Other services with 19.23%. Right after, there is the

Building and public works' sector with 11.01%. Despite for the other industries sector show that they count each 2% of the sample.

Sample's analysis according to the sector

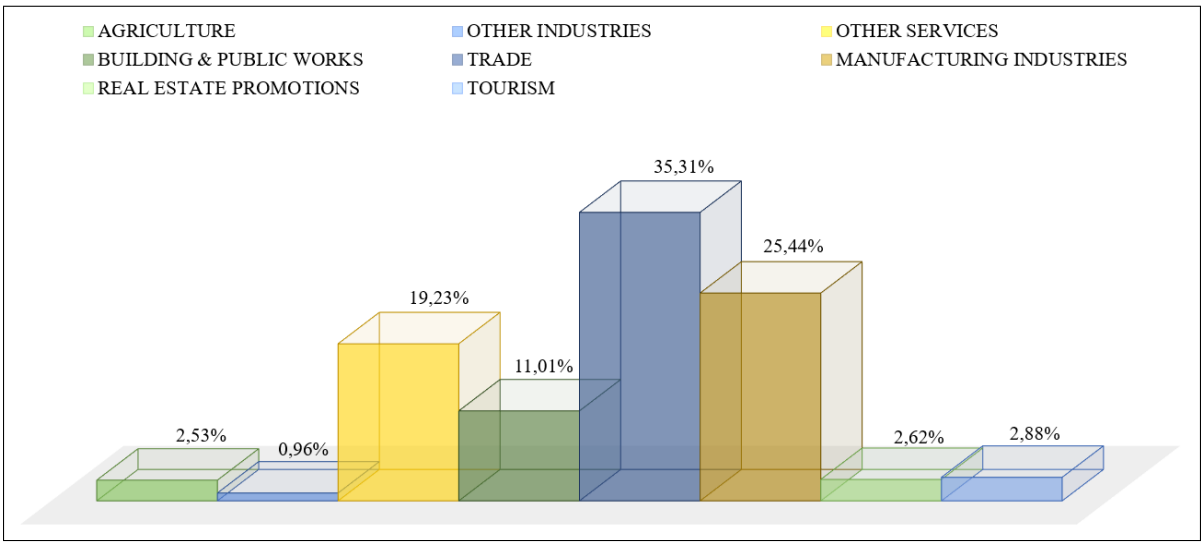

Figure 3.2 – Frequencies per sector

3.3 CreditRisk$^+$ implementation

In order to enable the implementation of the CreditRisk$^+$ model, we will need to use the R package called "Generalized Credit Portfolio Model". This package was established by (Jakob & Fischer, 2016), aiming to provide an efficient tool for the default risk analyze of credit portfolios with commonly known models. One of those being the CreditRisk$^+$ model. With this package, available on the R database [1]. In order to be able to compute use the GCPM package, one must prepare the input data so they can be implemented as needed.

3.3.1 Input data

In order to be able to conduct this dissertation, one must provide the following set of information on each counterparty i :

- **Exposure at default EAD_i**

  EAD is a measure of a bank's exposure towards a defaulting counterparty. For certain

[1] https://cran.r-project.org

balance sheet items, EAD is accurately known, the value is equal to the nominal amount outstanding at the calculation date. However, measuring the amount of exposure at the time of the default for financing commitments such as stand-by credits, revolving credits, requires an approximation of the EAD with a view to the uncertainty of future drawdowns, in this case EAD can be estimated on the basis of credit risk assessment models, where :

$$\text{EAD} = \text{Outstanding capital} + \text{Unpaid debts}$$

The sample studied count an exposition with a mean of 332.710,46 dinars.

- **Probability of default PD_i**

  From a statistical point of view the probability of default is equivalent to a random variable that can be estimated but one can never determine its true value because its determination depends on the assumption one assign to the realization of the event of default. It is important to be aware that the empirical equivalent to the probability of default, is named the default rate.

  In the sections below, an analysis on our SME sample is conduct in order to study the probability of default according to rating classes as well as the sector of activity. The mean probability of default category is used a representative index of each category.

Rating

The use of seven classes as required by the circular 2016-06. The appointment of classes is chosen taking as reference While setting those classes one must verify the increase in the probability of default from a class to another so that the upgrade or downgrade reflects as well the degradation or improvement of the borrower's solvency.

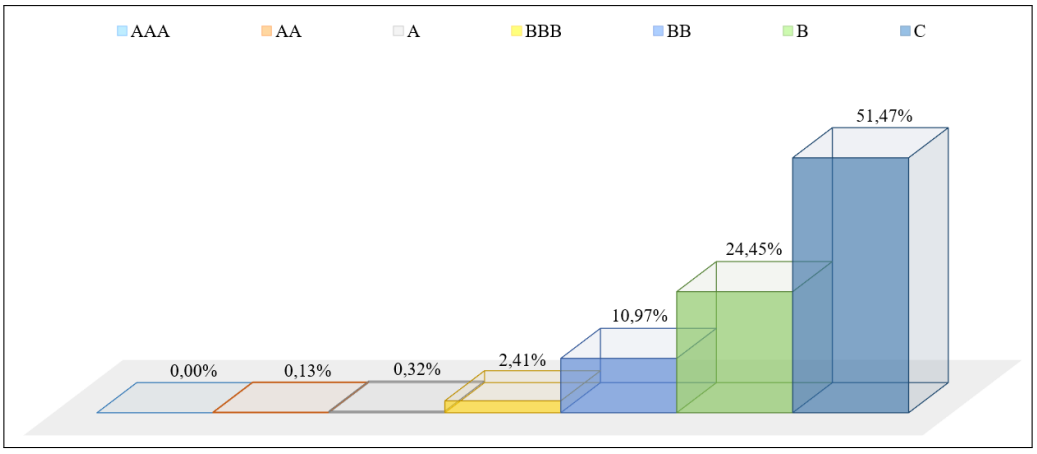

Figure 3.3 – The probability of default per rating

The displayed figure shows the mean probability of default per rating class. The results confirm the effectiveness of these rating classes : the probability increasing gradually from an average PD of 0,00% for class A to 51.4% for class C. One can notice that class AA and A have a PD of almost 0.00%. The upgrade is remarkable since the fourth class BBB with an average class of 2.41%, another jump up till 10,97% for class BB followed by a 24.45% for class 24.45%.

Sector

The analysis of the average PD per sector is interesting in the way it enlightens us about which sectors are riskier for the bank to invest in. Knowing the state of the sector's actual default rate, it would be relevant to pay more attention to the file so that it doesn't worsen the bank's portfolio credit risk.

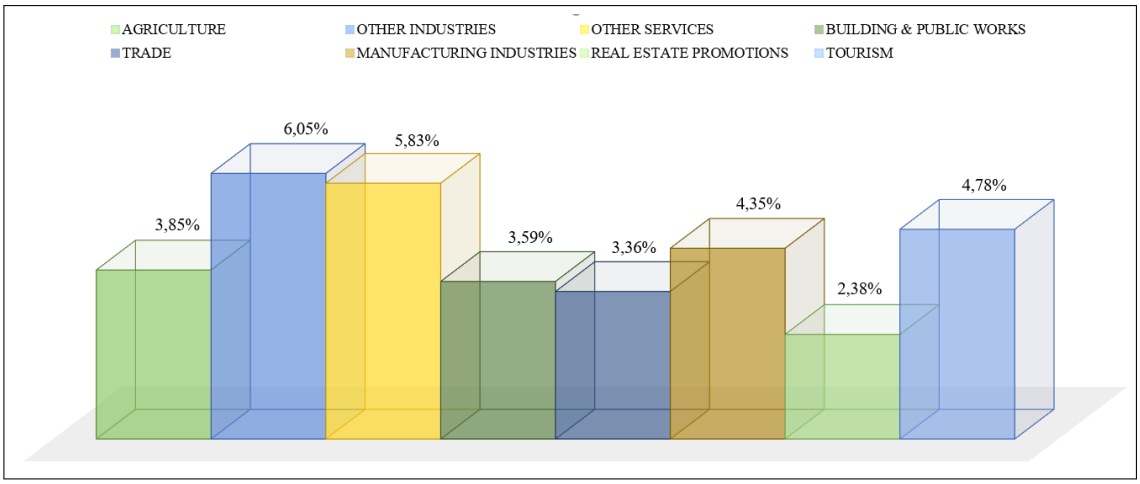

Figure 3.4 – The probability of default per sector

The sample shows a higher average PD for the "Other industries" sector; 6.05%, this sector includes activities such as the manufacturing of eyeglass frames, medical orthoses and so on[2]. The second place is awarded to the "Other services" sector with an average default rate of 5.83%, then the sector of "Tourism", 4.78%. The next place goes to the "Manufacturing industries" sector with an average PD of 4.35%, 3.85% for "Agriculture", 3.59% for "Building and Public Works", 3.36% for "Trade" sector and with the lowest default rate of 2.38%, the "real estate promotion" sector.

- **Loss given default LGD_i**

  The loss in the event of default is the percentage of the loss on the total exposure, in the event that a counterparty fails. Thus, it is measured by the ratio of the loss on a borrower's default exposure to the amount of the exposure at the time of the default,

$$LGD = \frac{\text{Amount of loss given default}}{EAD}$$

  In this dissertation, we estimate the loss given the event of default by deducting the value of the guarantees from the exposure at default.

  In addition, it should be known that in practice the date of default is not determined in a simple way, it is because the event of default is not the result of a single process defined with certainty.

[2]http://www.tunisieindustrie.nat.tn/

- The borrower PD variances according to predefined industry and/or country sectors in order to rebuild the dependence structure of the portfolio.

  The table lists the ratings standard deviation form which the input is derived :

Table 3.1 – The rating classes' standard deviation

Sector	Variances
Agriculture	0,88%
Other Industries	1,70%
Other Services	2,16%
Building & Public Works	1,00%
Trade	1,34%
Manufacturing Industries	2,32%
Real Estate Promotions	0,36%
Tourism	1,01%

For this dissertation, we will choose the industry type sectors as a dependence structure, knowing that the CreditRisk$^+$ model doesn't provide constraints allowing to choose which criterion is the most preferable.

3.3.2 Database display

In the table below, a part the input is shown to present the way input data were introduced to the package. To those data, one must add the PD variances' vector for each sector.

Table 3.2 – A database sample

Number	Name	Sector	Location	EAD	LGD	PD	Default	S1	S2	S3	S4	S5	S6	S7	S8
1	Name 1	Trade	Northeast	359352,8	0,75	0,000114	Poisson	0	0	0	0	1	0	0	0
2	Name 2	Other services	Northeast	46579,85	1	0,000114	Poisson	0	0	1	0	0	0	0	0
3	Name 3	Trade	Northeast	1233987,507	0,797	7,95E-05	Poisson	0	0	0	0	1	0	0	0
4	Name 4	Trade	Northeast	10098,68	1	0,000125	Poisson	0	0	0	0	1	0	0	0
5	Name 5	MI[3]	Northeast	348835,8	1	7E-05	Poisson	0	0	0	0	0	1	0	0

In the displayed table, the S_i for $i = 1..8$ refers respectively to Agriculture, Other industries, Other services, Building and public works, Trade, Manufacturing industries, Real estate pro-

motion and Tourism, where

$$S_i = \begin{cases} 1 & \text{if the SME} \in S_i \\ 0 & \text{if else} \end{cases}$$

Conclusion

Chapter 4

Empirical results

Introduction

4.1 The models' result analysis

In this context, the CreditRisk$^+$ model states the *ACP* designation referring to the "*Annual Credit Provision*". The *ACP*, whose value is equal to that of the expected loss, may not be sufficient to cover the loss given the uncertainty related to the environment. To remedy this, CreditRisk$^+$ introduces the "*Incremental Credit reserve*", known as *ICR*. This is the provision used to cover any overflow. Finally, the notion of *ICR Cap* is introduced, referring to the amount of the provision dedicated to extreme situations, generally defined as the 99^{th} percentile of the loss distribution.

In other words, the CreditRisk$^+$ refers to the expected loss as the *ACP*, the Value at Risk as the *ICR Cap* and the unexpected loss as the *ICR*.

The model's implementation on R, shows the first results. It first displays the output allowing the interpretation leading to the whole portfolio's credit risk determination. The probability distribution of losses is drawn in figure 4.1.

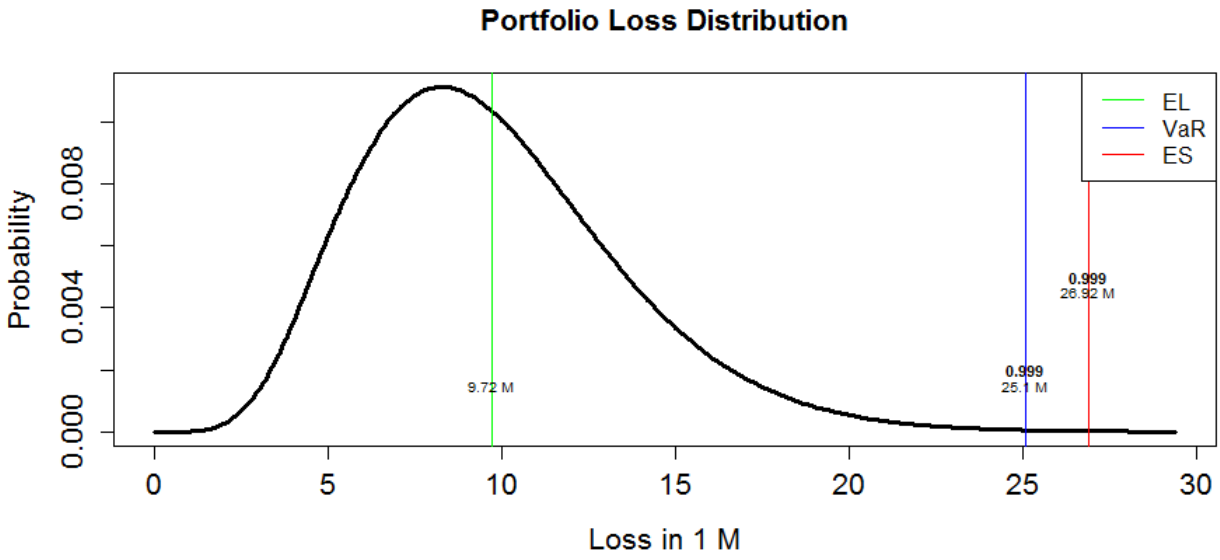

Figure 4.1 – Portfolio credit loss using CSFP model

The ACP amount determined by the model is of 9.72 M. At a confidence level of 99%, the value at Risk or *ICR cap* in CreditRisk$^+$'s terms reaches the 25.1 M. The expected shortfall representing the mean loss exceeding the *VaR* is of 28.52 M.

4.2 Expected loss

This section analyzes the expected loss or *ACP* in CreditRisk$^+$'s terms, according to rating classes and sector of activity. For a better appreciation of the expected loss and that it would not be biased by the categories' size, the latter figures display the average expected loss per borrower for each class.

Rating

In figure 4.2, the expected loss is expressed in terms of rating classes for a better appreciation and awareness of the need of each class's capital provision. The least average exposure of AAA rating class is of 51 MD, class AA's average *ACP* per counterpart is of 227 MD, followed by 1016 MD for class A.

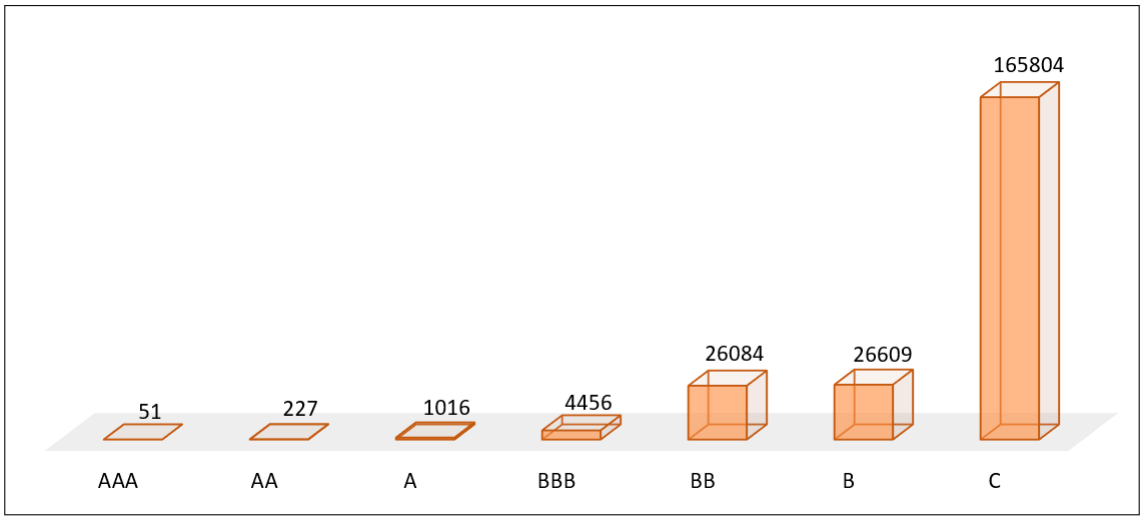

Figure 4.2 – The average expected loss per rating and per SME

The B classes (BBB, BB and B) count 25.79% of the total expected loss (Table 4.1). The counterparts for class BBB's EL is of 4.456 MD, for class BB and B, the The class C itself representing 4.02% of the sample's size (Fig 3.1) holds 71.05% of the global expected loss per counterpart.

Table 4.1 – Rating class expected loss as percentage of the whole

Rating	AAA	AA	A	BBB	BB	B	C
% EL[1]	0,15%	0,60%	2,42%	7,18%	11,42%	7,19%	71,05%

Sector

The average EL per sector highlights the agriculture high ACP needed for the SMEs belonging to this sector which is determined to be equal to 48.106 MD, holding 12.995% of the portfolio's EL. Then, followed by the real estate promotions and manufacturing industries which EL per SME is, respectively, 19.773 MD and 14.937 MD. The heaviest sector being the manufacturing industries sector mobilizing 40.5% of the portfolio dedicated ACP.

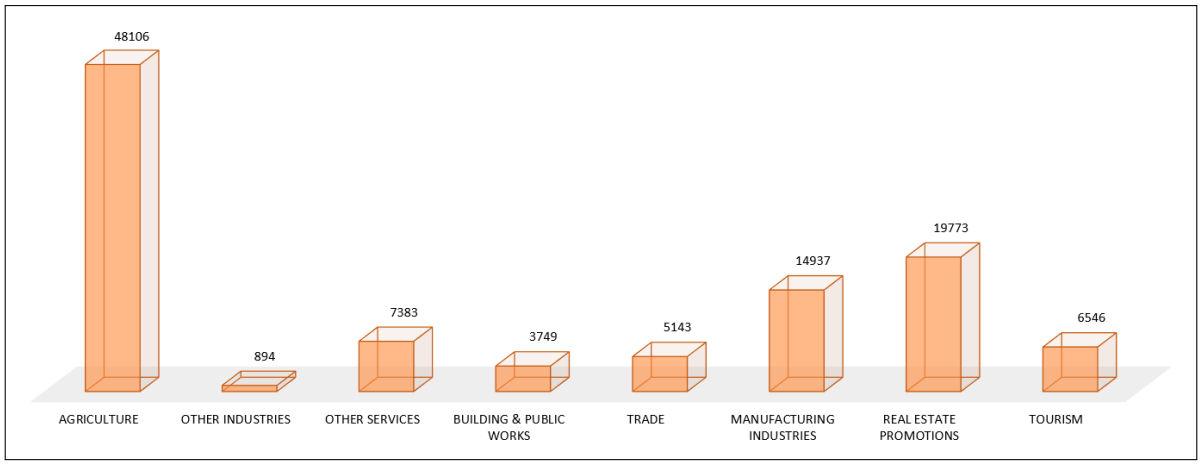

Figure 4.3 – The average expected loss per sector and per SME

The least needy SMEs being with an expected , those which belong to the other industries' sector (0.092% of the portfolio's EL). The building and public industries' counterparts needs is of 5.749 MD per counterpart (the sector takes 4.4% of the global EL), other services sector belonging SMEs need to be provisioned up to 7.383 MD (15.13% of the portfolio's EL).

Table 4.2 – Sector of activity expected loss as percentage of the whole

SECTOR	AGRICULTURE	OTHER INDUSTRIES	OTHER SERVICES	BUILDING & PUBLIC WORKS
% EL	12,995%	0,092%	15,130%	4,4%

SECTOR	TRADE	MANUFACTURING INDUSTRIES	REAL ESTATE PROMOTIONS	TOURISM
% EL	19,356%	40,490%	5,525%	2,012%

4.3 Economic capital analysis

The economic capital represent the capital required to cover the unexpected loss at a defined confidence level. Figure 4.4 shows the EC evolution according to the confidence level's. One can remark that the capital increases of 1 MD approximatively each time the confidence level rises by 1%. However, the EC makes a jump up of 9 MD. The GCPM package has another particularity which is to determine each counterpart's contribution to the credit risk measures. This specificity enables the credit manager to pursue a more effective and precise strategy, in the same time minimize the portfolio's credit risk, as well as prevent for each counterpart's eventual failure.

Confidence level (%)	Economic Capital (MD)
95	6.877
96	7.477
97	8.177
98	9.077
99	10.677
99.9	19.677

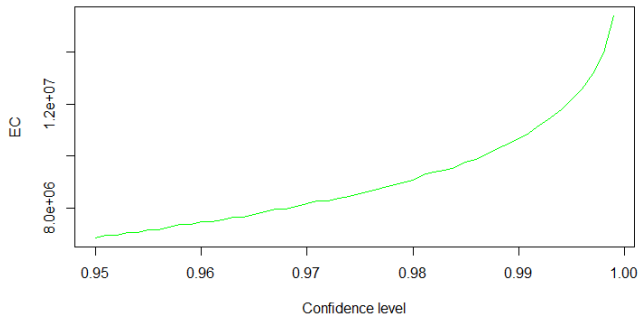

Figure 4.4 – Economic capital in terms of confidence level

Another advantage to the analysis of each counterpart's contribution is that it allows a better analysis, removing the diversification effect on reducing the portfolio's global credit risk. Figure 4.5 displays the SMEs contribution to the economic capital at a confidence level of 99.99%. It should be noted that the counterparts are sorted from rating class AAA till C, which is of great help to simplify the interpretation. The black lines represent the transition from one class to another.

Counterpart number	EC contribution (MD)
1140	3.604
1101	2.076
1118	0.935
1086	0.803
1116	0.776

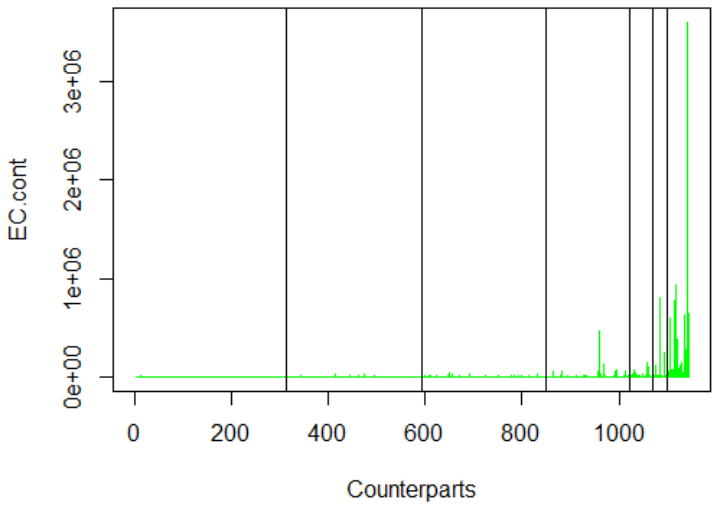

Figure 4.5 – SMEs' contribution to EC at a confidence level of 99.99%

The figure shows a pretty low EC requirement for SMEs belonging to rating classes AAA, AA, A and BBB, BB. However, for rating classes B and C the requirements jump up affecting the whole portfolio's state in terms of mobilized capital. This analysis allows the credit manager

to detect which SMEs to focus on and that could absorb the provisions : in this case the riskier counterpart to focus on belongs to rating class C, the SME number 1140 which EC contribution is of 3.604 MD is the most needy, the second place is taken by the SME number 1101 with an EC contribution of amount equal to 2.076 MD.

4.4 Value at risk analysis

Confidence level (%)	VaR (MD)
95	16.6
96	17.2
97	17.9
98	18.8
99	20.4
99.9	29.4

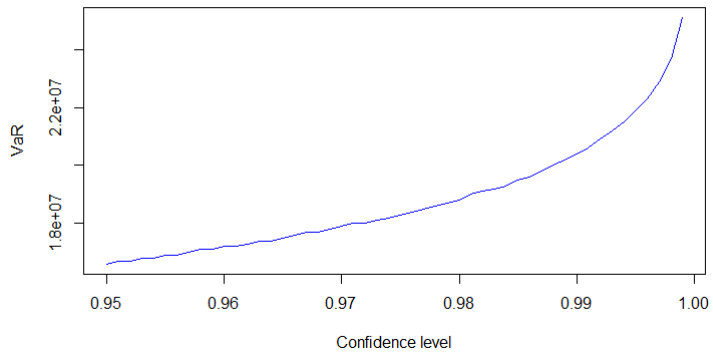

Figure 4.6 – Value at Risk in terms of confidence level

The previously displayed figure describes the maximum potential loss according to the confidence level. At 99.99%, the VaR is estimated to 29.4 MD.

Counterpart number	VaR contribution (MD)
1140	8.231
1101	3.458
961	2.055
1086	1.201
1118	1.117

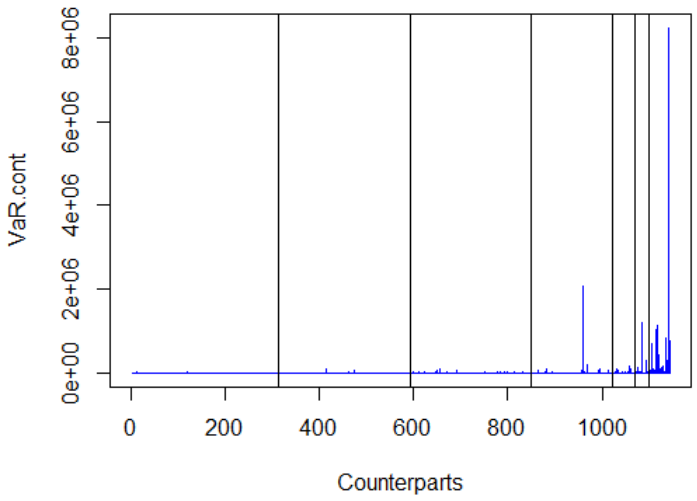

Figure 4.7 – Counterparts contribution to VaR at 99.99% confidence level

The value at Risk is of great weight for the case of the SME number 1040 (8.231 MD) followed by the SME number 1101 (3.458 MD), both belonging to the rating class C. It is though different for the third place held by SME number 961 (2.055 MD)where the third place in terms of high EC requirement falls to the fifth place with a maximum potential loss of 1.117 MD.

4.5 Expected shortfall analysis

The figure 4.8 displays the evolution of the mean potential loss in case the latter exceeds the VaR estimation. Though the ES amounts are close to each other for confidence levels from 95% till 99%, it goes up consequently while estimating it at the level of 99.99%.

Confidence level	Expected shortfall (MD)
95	18.879
96	19.430
97	20.078
98	20.917
99	22.422
99.9	31.085

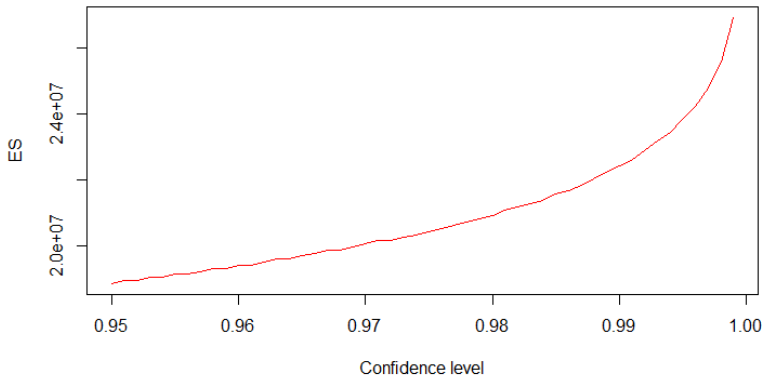

Figure 4.8 – Expected shortfall in terms of confidence level

As for the classification established while determining each counterpart's contribution to the *VaR*, the expected shortfall maintains the same ranking. The SMEs found belong to the rating class C except for the SME number 961 which has a rating class B.

Counterpart number	ES contribution (MD)
1140	9.116
1101	3.680
961	2.454
1086	1.261
1118	1.142

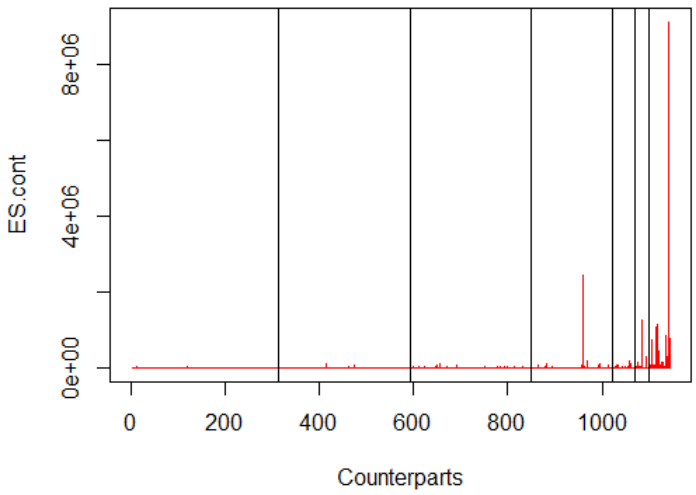

Figure 4.9 – Counterparts contribution to ES at 99.99% confidence level

Conclusion

General conclusion

Bibliography

K. Jakob and M. Fischer. Gcpm: A flexible package to explore credit portfolio risk. *Austrian Journal of Statistics*, 45:25–44, 2016.