Evaluating the Predictive Efficiency of the CAGEX-Rating System in Managing Bank Credit Risks: Evidence from Algerian Small and Medium Enterprises

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Abstract:

This study aimed to test the predictive power of the local credit rating model "Cagex Rating" within the Algerian banking sector, employing the binary logistic regression method. The study sample included 65 economic firms (both sound and defaulting) operating in various sectors, based on a set of quantitative variables (debt-to-equity ratio) and qualitative variables (credit history, management quality, and business diversification). The study concluded that the model demonstrated high discriminatory efficiency and significant discriminatory ability among firms, with a correct classification rate exceeding 95% and robust goodness-of-fit indicators. The results also demonstrated the important role played by qualitative variables, particularly credit history, management competence, and business diversification, as decisive factors in explaining the probability of default in the Algerian banking sector.

Keywords: Credit Risk Rating; Cagex Rating Model; Binary Logistic Regression; Algerian Firms; Default Probability.

Jel Classification Codes : G32 ; G21; C25

ملخص:

هدفت هذه الدراسة إلى اختبار القدرة التنبؤية لنموذج التصنيف الائتماني المحلي «Cagex Rating» في القطاع البنكي الجزائري، باستخدام طريقة الانحدار اللوجستي الثنائي. وشملت عينة الدراسة 65 شركة اقتصادية (سليمة ومتعثرة على حد سواء) تعمل في قطاعات مختلفة، استنادًا إلى مجموعة من المتغيرات الكمية (نسبة الدين إلى حقوق الملكية) والمتغيرات النوعية (السجل الائتماني، وجودة الإدارة، وتنويع الأنشطة التجارية). وخلصت الدراسة إلى أن النموذج أظهر كفاءة تمييزية عالية وقدرة تمييزية كبيرة بين الشركات، بمعدل تصنيف صحيح تجاوز 95٪ ومؤشرات قوية لمدى ملاءمة النموذج. كما أظهرت النتائج الدور المهم الذي تلعبه المتغيرات النوعية — لا سيما السجل الائتماني وكفاءة الإدارة وتنويع الأعمال كعوامل حاسمة في تفسير احتمالية التخلف عن السداد في القطاع المصرفي الجزائري .

الكلمات المفتاح : تصنيف مخاطر الائتمان؛ نموذج تصنيف Cagex؛ الانحدار اللوجستي الثنائي؛ المؤسسات الجزائرية؛ احتمال التعثر .

تصنيف JEL : C25 ; G21; G32

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I. Introduction:

Credit risk management is the cornerstone of banks' profitability and the sustainability of their financial stability. While Western banks have successfully strengthened their competitive advantage by developing sophisticated internal rating systems designed to maximize returns while minimizing potential losses, the Algerian banking system continues to face major challenges in designing internal or local rating models that reflect the specific characteristics of its economic environment.

It has become necessary to use local credit risk rating models that incorporate all local market variables and truly reflect the level of risk to which Algerian banks are exposed, thereby helping them improve their credit risk management mechanisms, achieve gradual compliance, and meet the recommendations of Basel III.

Algerian banks remain dependent on ratings from Standard & Poor's, in the absence of internal credit risk rating models, and face numerous challenges in adopting local rating models tailored to the specificities of the economic environment in which they operate and their client base, prompting them to address these challenges in order to implement local models that enable them to accurately assess credit risks and determine the capital reserves needed to cover expected losses.

I.1- Research Question:

In this context, the present study is of paramount importance as it highlights the Cagex Rating model as a local approach and aims to measure the accuracy of this model in the credit risk rating process for a sample of Algerian institutions. Within this context, the research problem centers around the following fundamental question:

Is the predictive accuracy of the CAGEX-Rating model sufficient for classifying **Algerian firms** in a manner that enhances **the effectiveness of credit risk management in banks?**

The main question gives rise to the following sub-questions:

- What are the determinants of the CAGEX-Rating model, and how does it incorporate financial and qualitative criteria?
- Are there statistically significant differences between the model's ratings and companies' actual repayment performance (using logistic regression)?
- How does the adoption of this model contribute to reducing "default risk" among Algerian banks compared to traditional methods?

I.2- Research Hypotheses:

In light of the research problem and its sub-questions, we propose the following three hypotheses to be examined throughout this study:

H1-The Cagex-Rating model relies on the integration of financial and qualitative indicators to perform a comprehensive assessment of corporate risks.

H2- The Cagex-Rating model possesses a statistically significant discriminatory capacity to predict the default risks of the companies studied.

H3 – The adoption of the Cagex rating by Algerian banks improves the accuracy of credit decisions and reduces the volume of non-performing loans.

I.3-Significance of the study:

The significance of this study lies in the fact that it examines the effectiveness and relevance of a local credit risk rating model-namely, the "Cagex-Rating" model—as applied to Algerian banks, It also addresses certain challenges these banks face in assessing their customers' credit risks, particularly in the absence of internal models that would allow them to measure these risks based on the specific characteristics of their economic environment. This will help improve credit decision-making mechanisms and reduce levels of non-performing loans.

I.4-Objectives of the study:

The objectives are as follows:

- To highlight the operational mechanisms of the Cagex-Rating model and explain the hybrid criteria-both quantitative and qualitative-on which it is based for classifying the credit risks of Algerian institutions
- Analyze the statistical effectiveness of the model using logistic regression to assess its ability to distinguish between institutions in default and those that meet their obligations
- To assess the accuracy of credit decisions and the model's precision in predicting credit defaults using advanced statistical tools
- To examine the feasibility of adopting the Cagex-Rating model, within Algerian banks to improve credit risk management.

I.5-Study Methodology:

A descriptive and analytical approach was adopted to examine the theoretical aspects. In addition, a statistical analysis was conducted using binary logistic regression, considered one of the appropriate statistical methods for modeling the relationship between the dependent variable, which is binary, representing the firm's status as either (default or non-default) and the independent variables, in order to assess the accuracy of the Cagex-Rating model in classifying companies in the Algerian banking sector. The sample comprised 65 Algerian firms from various sectors, selected based on the availability of data from the Cagex database, and included a number of independent variables, some of which were quantitative and others qualitative**.** Table (1) presents a summary of the data used in the analysis. The sample consisted of 65 firms, with no missing observations, which enhances the robustness and accuracy of the statistical analysis.

Table 01. Summary of the Analysis of the Study Sample

Summary of Observation Handling			
Unweightedobservations[a]		N	Percentage
Selected observations	Included in the analysis	65	100,0
	Missing observations	0	,0
	Total	65	100,0
Unselected observations		0	,0
Total		65	100,0
a. If weighting is enabled, refer to the classification table for the total number of observations.			

Source: Prepared by the researcher based on the output of the SPSS program

I.6-Study Variables:

- **Dependent variable**: Default/Non-default status, which is a binary variable representing the institution's ability to repay loans.
- **Independent variables**: These include a set of quantitative and qualitative variables, namely:
  - Return on debt ratio (RODR), which represents the ratio of profitability to debt
  - Management Efficiency;
  - credit history;
  - Activity Diversification

I.7- Literature Review:

This section reviews the key previous studies on this topic, categorizing theminto Arab and international contexts, while highlighting studies focusing specifically on the Algerian context, as follows:

I.7-1-Arab and International Studies:

- The study conducted by (Matoussi& Abdelmoula, 2010):aimed to evaluate the predictive performance of three credit risk assessment methodologies: scoring models, logistic regression, and artificial neural networks. The study was based on a large-scale dataset comprising 1,435 loan applications from Tunisian industrial firms, collected over a four-year period (2003–2006). The results showed that artificial neural networks significantly exceeded traditional methods in predicting the financial challenges faced by borrowing companies. The ANN approach also achieved a high classification accuracy of 97% for the training dataset and 89.9% for the test dataset, confirming its effectiveness in predicting default risk.

- Study (Bekhet & Eletter, 2014)**:** This study aims to address the gap in adopting advanced statistical tools, such as artificial neural networks, within Jordanian commercial banks. Two models were introduced to evaluate creditworthiness using data mining techniques. For the analysis, a dataset of loan applications—categorized into approved and rejected cases from various Jordanian banks—served as the basis. Key findings revealed that the logistic regression model demonstrated slightly higher overall accuracy compared to the Basic Radial Basis Function (BRF) model. However, the BRF model showed superior performance in identifying customers at a high risk of loan default.

- Study (Chen et al., 2024)**:**This study aimed to develop credit solutions specifically tailored to meet the needs of small and medium-sized enterprises. It used a logistic regression model to analyze large-scale data drawn from bank credit records. One of the most important findings of the study is that the use of big data and advanced analytical tools is of considerable importance for efficient financial risk management, particularly with regard to lending operations in the SME sector.

- Study (Fathy et al., 2024)**:** The study focused on developing a predictive model using machine learning (ML) algorithms to assist in making correct credit decisions and protecting banks' financial assets. To this end, five classification algorithms were applied—namely, Artificial Neural Networks (ANN), Random Forest (RF), Logistic Regression (LR), Decision Tree (DT), and XG Boost to a historical data from one of Egypt's leading banks. The most significant conclusions reached the distinctive role of artificial intelligence in advancing credit risk management and enhancing the stability of financial institutions. It was also found that the XG Boost model achieved the highest predictive performance.

- Study (Ou, 2025)**:**The research focused on assessing credit risks associated with small and medium-sized enterprises (SMEs) by applying advanced machine learning models, including logistic regression, decision trees, random forests, Light GBM, Cat Boost, and multilayer perceptrons (MLPs). This was done using publicly available databases. The study showed that the Light GBM-based model demonstrated superior performance compared to other methodologies. It also revealed that certain indicators, such as company size, financial performance, and employee welfare stability, are critical factors in credit risk assessment.

- In light of the studies outlined above, which reviewed a selection of Arab and international research, it is evident that these banks are increasingly turning to machine learning models—such as decision trees, random forests, logistic regression, and others—to predict credit risk, moving away from traditional methods. This reflects the gap that remains in the application of these advanced models within the Algerian banking sector.

I.7-1-- Local Studies:

In light of the limited accounting information provided by institutions to the Algerian banking sector, a study by Gliz and Touati-Tliba addressed the field of credit risk assessment by analyzing a set of banking data using a statistical model. The study concluded that among the accounting data influencing credit risk assessment are debt levels and cash flow, while the profitability ratio remains weak in terms of impact, reflecting the underreporting of firms' actual revenues amid the prevalence of the informal economy. The study also pointed to other mechanisms used by banks to overcome such challenges, namely by relying on reliable external information such as business volume and the tax status of institutions.(Gliz& Touati-Tliba, 2012).

On the other hand, a study (Oukil & Ben Khaled, 2013)examined the various applications of logistic regression models and then applied this model to a sample of 33 borrowing institutions from the Bank of Agriculture and Rural Development. It concluded that logistic regression models are a powerful tool for predicting defaults and can be utilized by Algerian banks. In the same vein, a study by (Fakhari & Yah, 2019) demonstrated the importance of using statistical tools to predict customer defaults, given the limited predictive power of traditional financial methods. The study included a comparison of a set of previous studies that utilized various statistical techniques. The study considered the logistic model to be the most suitable option for predicting loan defaults compared to some other statistical models used by other researchers, a view we strongly support given the reality of the Algerian banking environment.

Meanwhile, the study undertaken by(Adesanya, 2024) presented a comparison between traditional and modern models, showing the importance of using modern approaches based on machine learning and big data analysis in assessing borrowers' creditworthiness, compared to traditional techniques such as financial analysis and credit scoring systems. Among the most notable findings is the limitation of traditional models, particularly their reliance on historical data and their disregard for dynamic economic changes and the changing behavior of borrowers—a distinction that sets modern models apart, as they utilize extensive data from credit records, consumption behavior, and future projections. Here, we see a trend toward using artificial intelligence and machine learning algorithms to enhance credit risk assessment processes.

Based on a review of the studies outlined above, we conclude that traditional credit risk assessment models used in some Arab countries have shortcomings, and that there is a growing trend in some of these countries (Jordan, Egypt, Kuwait) toward adopting modern models. Furthermore, improving the accuracy of credit decisions and moving away from subjective judgments can only be achieved by relying on quantitative models and artificial intelligence tools. It is also essential to ensure that the conditions for the effectiveness of these models are present in the local environment. Here, we raise questions regarding the effectiveness of applying local models in the Algerian banking sector.

What distinguishes our study is its aim to improve credit risk management within a specific banking environment that continues to rely on limited traditional methods for risk prediction. Thus, we attempt to measure the accuracy of the local "Cagex" model in predicting defaults for a sample of Algerian institutions using binary logistic regression.

II. -Theoretical Framework of the Study:

Studies have shown that the ratings applied by banks in emerging markets—which are derived from the standard models of international rating agencies—are inaccurate in measuring actual risk, which negatively impacts capital allocations intended to cover expected losses.

In this context, Algerian banks also suffer from the repercussions of applying Standard & Poor's ratings, which were adopted in the absence of an internal model for assessing credit risk, as well as to meet the regulatory requirements stipulated by the Basel Committee. Among the shortcomings noted are inconsistencies in information and the nature of the Algerian economic environment compared to the assessment environment relied upon by international rating agencies.

Given this situation, the need to shift toward the application of internal credit risk rating models becomes evident, in order to enhance the accuracy and flexibility of the credit decision-making process. The Cagex model emerges as a local alternative that is better aligned with the characteristics of the Algerian banking environment and contributes to improving the accuracy of credit risk assessment.

II.1Theoretical Literature on Credit Rating Models:

II.1.1The Shift from Descriptive Assessment to Quantitative Modeling:

In recent years, the banking sector has seen significant advancements in credit risk assessment, shifting from models based on empirical methods to complex statistical models and machine learning models, designed to assess risk factors such as probability of default, exposure at risk, and capital adequacy. (Kowsar, 2022, p. 5).

Traditional methods of credit risk assessment have been found to have limitations resulting from their reliance on historical data, which does not accurately reflect current and future market dynamics, as well as their subjective nature in the assessment process. They are also characterized by their inability to process vast amounts of complex and non-traditional information. This has prompted banks to shift toward quantitative methods based on data analysis, marking a qualitative change in modern banking practices.(Shittu, 2022, pp. 660–661)**;**(Nwachukwu et al., 2025, p. 7043).

The transition from subjective assessments to the use of discriminant analysis and financial ratios to predict defaults can be attributed to early research such as that conducted by Altman (1968) and Beever (1966). One of the oldest statistical methods applied in assessing credit risk at the institutional level is discriminant analysis. This technique involves a combination of financial ratios or characteristics associated with borrowers, who are classified into two groups: one group likely to default and another likely to be non-defaulting. (One prominent application is the Altman Z-score model). This method has several limitations, the most significant of which is its reliance on normally distributed data. This has often resulted in errors in the rating process.

The response to these criticisms involved the use of logistic regression, which does not rely on the normal distribution of the sample data under study. This method links borrower characteristics to a binary dependent variable (default or no default) using a logistic function. It includes a set of independent variables: financial ratios, credit history, demographic data, and macroeconomic indicators**(**Nwachukwu et al., 2025, p. 7045).

In view of the significant and rapid technological advancements in recent years, financial institutions have undergone a remarkable shift toward using modeling to measure credit risk, as artificial intelligence and machine learning techniques have been integrated into the credit application analysis process. This is due to the advantages they offer, which are linked to their efficiency in making complex decisions and incorporating unstructured data, as well as the use of continuous learning, which enhances the accuracy of predictions(Shittu, 2022, p. 661).

The incorporation of modern techniques into credit risk assessment modeling stems from their numerous advantages, which have enabled the banking sector to accurately and early assess the probability of default (PD) of borrowers—a key foundation for the development of contemporary internal rating systems.

In this context, this study aims to determine the predictive power of the Cagex rating model in classifying Algerian companies (default or non-default), as a locally developed model closely linked to variables specific to the Algerian economic environment, using a binary logistic regression model.

II.1.2-The Basel Accords and Internal Ratings-Based (IRB) Approaches:

The Basel Committee established the Basel II framework, which comprised three key pillars: capital adequacy requirements, prudential supervision, and market discipline. This was followed by Basel III, which introduced additional reforms designed to strengthen this regulatory framework.(**Dhima, 2020, p. 33).**

The process of measuring minimum capital requirements for banking institutions is carried out according to three options: the standard approach, the simplified approach, and the advanced approach based on internal ratings (**Dhima, 2020, p. 3**5). As for the application of these internal approaches, this requires the development and use of an internal credit risk assessment system (**Dudian Monica, 2009, p. 71**).

Most aspects of the IRB Approach framework have been designed to ensure that risk factors can be identified, measured, and verified separately by both banks and supervisory authorities. The key inputs for this approach consist of the following risk elements: probability of default (PD), loss given default (LGD), exposure at default (EAD), and time to maturity (M).(Committee & Supervision, 2001, p. 4).

It should be noted that the Basel Accord guidelines allowed banks to use external rating agencies or specialized systems as a reference for assessing the risks of small and medium-sized enterprises. Recommendations have been made to limit automatic reliance on external ratings, particularly for banks that are unable to adopt an internal rating system or are unwilling to use external ratings, by proposing a detailed approach to national supervisory authorities (BCBS, 2017, p. 2)**.**

On the other hand, it should be noted that the Internal Ratings-Based (IRB) approach is not without its shortcomings, including: excessive complexity, the inability to compare capital requirements derived from these models across different banks, and the lack of robustness of the models used for certain asset classes. (BCBS, 2017, p. 5).

From the above, we conclude that the Basel Committee has granted banks the option to use their own models provided they have high predictive accuracy, because the ultimate goal of any rating system, whether external or internal, or local, such as the Cagex-Rating model, is to estimate the key variable represented by the probability of default (PD).

II..13-The Challenge of Model Suitability for Emerging Markets:

There is an urgent need to develop credit risk assessment models in banks in emerging economies. Take, for example, the case of Egyptian banks, which must work to improve the efficiency of the models they apply. This calls for a set of measures, the most important of which involve financial technology to meet modern technical requirements, training staff to manage these advanced systems, and working to improve regulatory frameworks.(Wagdi & Tarek, 2022, p. 40)

In this context, banks in emerging markets rely on external rating systems to classify their institutions, systems that are primarily based on quantitative variables (financial indicators) reported by the institutions themselves. This quantitative data often fails to reflect the actual economic reality of the surrounding environment. This leads us to present an example related to East Asia and Latin America, where, among the financial indicators used, we note the ratio of equity to assets, which has proven ineffective in predicting defaults among borrowing institutions, whereas we find that this ratio is highly effective in developed countries. This is due to the weakness of the accounting framework and regulatory laws in these countries**.**(Liliana Rojas-Suarez, 2001, p. 1)**.** Here, we can note the similarity of this situation to that of developing countries, such as the Algerian banking sector, which continues to rely on financial indicators that do not truly reflect the actual economic performance of institutions**.**

This leads us to conclude that these banks are still unable to implement internal rating-based (IRB) models in accordance with the requirements of the Basel Accord. Some recent studies indicate that the development of these models in economies such as Bangladesh—where banks face numerous obstacles, including the lack of regulatory frameworks, insufficient data, institutions' unwillingness to implement these models, and the absence of relevant social and economic contexts—is particularly challenging. It has also been noted that there is a fundamental weakness in the design of these models or in verifying the accuracy of their predictions, namely the disregard for operational and infrastructure-related challenges faced by these banks (incomplete credit records, poor digital record-keeping, and a lack of transparency on the part of borrowers.(Kowsar, 2022, p. 5).

We conclude from the foregoing that banks in emerging economies must strive to remove all existing obstacles that prevent them from establishing advanced credit risk rating models tailored to local conditions in a manner consistent with the characteristics of their environment, thereby overcoming the limitations of traditional models in predicting risk. To achieve this, they must redouble their efforts to address the shortcomings that hinder their implementation, particularly with regard to data, the economic and social environment, the use of the latest artificial intelligence technologies, and the training of staff and management in the banking sector.

II.2-The Nature and Mechanism of the CAGEX-Rating Model:

II.2-1 Introduction to the CAGEX-Rating System:

Term of "Rating" is an American term meaning "evaluation" or "rating". It is defined as: "a process for evaluating the risk attached to a debt security, summarized in a rating, enabling a classification to be made on the basis of the particular characteristics of the security offered and the guarantees offered by the issuer (Omrani et al., 2023, p. 20).

Cagex-Rating is a credit rating system based on an analytical method for assessing credit risk and assigning ratings, used by financial institutions to evaluate the creditworthiness of companies and individuals. It combines quantitative (financial ratios) and qualitative (industry sector and corporate management) analyses to assign a risk rating to each borrower. This rating determines the probability of default and influences lending decisions. It is therefore a model for measuring, assessing, and predicting the risk of default on bank loans granted to economic entities in the start-up or growth phase. It focuses on repayment capacity (creditworthiness) in the short and medium term.

This model takes into account national and international standards. The rating is provided as a service to Algerian public banks that are partners with the "Algerian Export Credit and Guarantee Corporation" (Cagex), governed by Article 4 of Ordinance 96/06 of January 10, 1996, concerning export credit insurance. It was established on December 3, 1996, with the aim of encouraging and promoting Algerian exports other than hydrocarbons. A public company incorporated as a joint-stock company with a capital of 10,000,000,000 Algerian dinars, divided equally among its shareholders, which include insurance companies (CAAR, CAAT, CASH, CCR, CNMA, and SAA) and the five public banks (CPA, BDL, BADR, BNA, and BEA).(Cagex, n.d.-a)

It should be noted that the company offers its clients a wide range of products, including export credit insurance, trade fair insurance, debt collection, and the sale of economic and financial information and corporate credit ratings.

II.2-2- Content and Mechanisms of the 'CAGEX-Rating' Model:

This model is designed to study and analyze the risks tied to the economic and financial health of companies by gathering a wide range of relevant data. Its main goal is to identify potential vulnerabilities early and assess credit risks effectively. Additionally, it examines key factors associated with institutions, such as management, strategic direction, and industry-specific elements that can influence their capacity to generate profits and fulfill financial commitments. The model also aims to support institutions with favorable prospects and initiatives that show strong potential for growth.

This mechanism explains how raw data is converted into a specific rating or level that reflects the probability of default. In this context, the process of assessing institutions involves several sequential steps based on a specific methodology and specialized software. This process relies on a set of quantitative and qualitative variables, which can be summarized and presented as follows (**Cagex, n.d.-b**):

1. **Financial ratios**:

Ratio	Formula	Optimal Level	Ability to cover short-term debt..
Current Ratio	CurrentAssets / CurrentLiabilities	> 1,5	Ability to cover short-term debt without selling inventory.
Quick Ratio	(CurrentAssets - Inventory) / CurrentLiabilities	> 1,0	Debt-to-equity ratio.
Net Debt	Net Debt / Equity	< 50 %	Gross profit margin relative to revenue.
Net Profit Margin	Net Profit / Revenue	> 5 %	Return on shareholders' equity.
Return on Equity (ROE)	Net Profit / Equity	> 10 %	Inventory management efficiency.
Inventory Turnover	Cost of Sales / Average Inventory	Depends on the sector	Ability to cover short-term debt.

2. Quality Standards:

Variable	Description	Rating scalefrom 1 to 5
Management Quality	The management team's experience, competence, and vision.	1: Poor, 5: Excellent
Market Position	Market share, reputation, and competitive advantage.	1: Poor, 5: Strong
GrowthStrategy	The clarity and feasibility of development plans.	1: Absent, 5: Veryclear
IndustryRisks	The stability and prospects of the industry.	1: High risk, 5: Lowrisk
Customer/Supplier Relationships	The diversity and strength of business relationships.	1: Poor, 5: Excellent

- SME/PMI Analysis Network (Investment Loan):

Standard	Sub-criterion	Weight	Optimal Value	Result (1 to 5)
Financial Ratios	Overallliquidity	20 %	> 1,5	
	Net debt	20 %	>50%	
	Net profitability	15 %	> 5%	
Quality of Management	Management experience	10 %	4 or 5	
	Growthstrategy	10 %	4 or 5	
Industry Sector	Industrystability	10 %	4 or 5	
	Competition	5 %	3 or more	
CreditHistory	Pastpaymentdelays	10 %	No delay	

- How to Set Up Analysis Networks:

The purpose of this table is to illustrate the steps for setting up analysis networks for the quantitative variables in the 'CAGEX-Rating' model. The example shown in the table below applies to all quantitative variables included in this model.

Table 02. Steps for Setting Up Analysis Networks

Step	Description	Example
Definecriteria	Select appropriateindicators (Financial and non-Financial)	Liquidity ratios, management quality
Weighting	Assign a weight to each criterion based on its importance	Liquidity: 20%, Debt: 20%
Set thresholds	Define thresholds for each criterion (Good, Acceptable, Critical)	Liquidity greater than 1.5 is good
Verification	Test the models on real-world scenarios to fine-tune the weights and thresholds.	Adjust thresholds after analyzing a set of files

Source: Prepared by the author based on CAGEX internal documents(**Cagex, n.d.-c**)

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This model is based on several approaches, including statistical methods for analyzing past trends (historical data) to predict the risk of delay, qualitative models for assessing management quality, utilizing expert evaluations (management, diversification, and others), as well as hybrid models to conduct a comprehensive analysis of financial and operational risks (combining quantitative and qualitative analysis).

In this regard, we note that the process of applying the CAGEX rating model is complex, as it relies on 304 criteria for risk prediction, in addition to a questionnaire comprising more than 600 questions related to risk analysis factors. The analysis also relies on two matrices: the SWOT (Strengths, Weaknesses, Opportunities, and Threats) strategic analysis matrix and the M5 matrix (Materials, Methods, Equipment, Environment, and Workforce), as well as an analysis of various types of weaknesses linked to the main causes of business failure, an analysis of opportunities, threats, and market development potential, profitability potential through Porter's Five Forces, and an internal diagnosis that analyzes strengths and weaknesses and utilizes Porter's value chain.(ZIBANI, 2018, p. 119).

The Cagex-Rating model is based on a on an integrated analytical approach that combines several strategic assessment tools to understand risks, identify factors influencing corporate performance, and forecast growth and profitability potential.

- CAGEX-Rating Assessment Scale:

The CAGEX-Rating scale is divided into 10 categories, starting with Category AAA, which represents institutions characterized by an excellent (excellent financial solvency and extremely low risk) and extending down to the lowest category, D (default), which represents distressed institutions. The following table shows the rating categories for this model.

Table 03. CAGEX-Rating Scale

Scale	Rating Meaning
AAA	Excellent financial strength and very low risk
AA	Very good financial strength and low risk
A	Good financial strength and moderate risk
BBB	Acceptable financial strength, medium to high risk
BB	Weak financial strength and high risk
B	Weak financial strength and very high risk
CCC	Very weak financial strength and imminent risk of default
CC	Probability of default in the short term
C	Imminent default
D	Default

(Cagex, n.d.-a)

Based on this theoretical framework of how the Cagex system works, this applied study aims to test the accuracy of these outputs using a logistic regression model.

III. The Effectiveness of the CAGEX-Rating Model in Predicting Credit Risk:

III.1- 1. Description of the Study Sample:

Based on the theoretical framework that reviewed the theoretical literature on credit rating models and the nature and mechanisms of the Cagex-Rating model in credit risk classification, this section of the study aims to test the accuracy of the Cagex-Rating model in classifying the credit risk of Algerian institutions. The significance of this applied study lies in applying this model to the credit decision-making environment within Algerian banks, by analyzing a sample including 65 institutions active in various sectors (industrial, commercial, and service sectors), divided into 35 sound institutions and 30 distressed institutions. It should be noted that the small sample size was due to the difficulty in accessing financial and credit data, which was not readily available; nevertheless, it represents a sufficient sample for conducting the statistical analysis.

III.1- 2. Estimation of Model Parameters:

A logistic regression model was used based on the stepwise descent method to identify the most accurate explanatory determinants of enterprise failure. Table 2 below illustrates the estimation stages and statistical parameters of the independent variables.

Table 04. Results of Logistic Regression Parameter Estimation (Phase I and II)

Equation variables									
								Confidence interval 95% for EXP(B)	
		B	E.S	Wald	ddl	Sig.	Exp(B)	Minimum	Maximum
Step 1[a]	Management Efficiency	-3,749	1,771	4,483	1	,034	,024	,001	,757
	Return on debt ratio	-1,699	1,685	1,017	1	,313	,183	,007	4,970
	credit history	5,543	2,242	6,114	1	,013	255,451	3,156	20674,879
	Activity Diversification	-3,274	1,536	4,544	1	,033	,038	,002	,768
	Constant	2,743	2,929	,877	1	,349	15,537		
Step 2[a]	Management Efficiency	-3,888	1,677	5,375	1	,020	,020	,001	,548
	credit history	5,089	1,998	6,485	1	,011	162,190	3,229	8147,051
	Activity Diversification	-2,961	1,358	4,759	1	,029	,052	,004	,740
	Constant	2,440	2,676	,831	1	,362	11,475		
a. Variables introduced in Step 1: Management Efficiency, Return on debt ratio, credit history, Activity Diversification.									

Source: Prepared by the researcher based on SPSS software outputs

Based on the results presented in the table above, the following observations can be made:

The results of the first stage show that the variable “margin-to-debt ratio” was not statistically significant (Sig = 0.313 > 0.05), which led to its exclusion in the second stage using the stepwise elimination method. This result can be interpreted as indicating that the explanatory power of the qualitative indicators incorporated into the CAGEX-Rating model was more dominant and robust in predicting the financial health of the Algerian institutions under study, Furthermore, it highlights the limitations of relying exclusively on traditional financial ratios within an economic environment characterized by high levels of specificity.

In the second stage, the model settled on three variables with high statistical significance (Sig < 0.05). These are credit history with a p-value of 0.01, management with a p-value of 0.020, and the diversification variable with a p-value of 0.029. Furthermore, the coefficient (B) and Wald values indicate that the credit history variable is the strongest predictor of default probability (B = 5.089), while both management efficiency and business diversification play an inverse and protective role in reducing the probability of default, as confirmed by the (Exp B) values, which were less than one for these two variables, supporting the validity of the first hypothesis of the study

From a statistical perspective, the Odds Ratio (Exp (B)) values highlight substantial impact of the credit history variable as a primary risk driver, specifically, a negative credit history increases the odds of default by a factor of approximately 162. Conversely, management efficiency and activity diversification serve as protective factors, reducing these odds by approximately 98% and 95%, respectively. This variation in the values of (Exp(B)) confirms that the selected

qualitative variables not only explain the firm's status but also possess superior predictive power that contributes to the model's classification accuracy.

Based on the statistical estimation results provided in the preceding table, the estimated logistic regression equation for the study sample can be formulated as follows:

$$\text{Log}(p/1-p) = 2{,}440 + 5{,}089\ (\text{Credit history}) - 3{,}888\ (\text{Management Efficiency})$$

$$-2{,}961\ (\text{Activity Diversification})$$

III.1- 3- Goodness-of-Fit Test (Hosmer and Lemeshow):

This test is used to assess how well the estimated model fits the actual data. I obtained the results of this test, which are listed in the following table:

Table 05. Results of the Hosmer-Lemeshow Goodness-of-Fit Test

Test de Hosmer et Lemeshow			
Pas	Khi-carré	ddl	Sig.
1	,743	6	,994
2	1,344	4	,854

Source: Prepared by the researcher based on SPSS software outputs

This test is used to assess how well the estimated model fits the actual data. The results of this test are presented in the following table:

The table indicates the goodness of fit of the model to the observed data. We note that the significance level (Sig) in Step 2 reached 0.854, a value significantly greater than the significance level of 0.05. Statistically, this implies acceptance of the null hypothesis, which indicates that there are no substantial differences between the actual values of the institutions (healthy vs distressed) and the values predicted by the Cagex-Rating model, This confirms the robustness of the estimated model and its validity in capturing the relationship between the independent variables (both qualitative and financial) and the probability of default within the study sample

III.1- 3-Classification Matrix:

Based on the results obtained from SPSS regarding the classification matrix, which reflects the model's predictive power, the results can be presented in the following table:

Table 6: Classification Matrix

Classification table [a]					
			Predictions		
			Risk Class		Correct
	Observed		Non-default	default	percentage
Pas 1	Risk Class	Non-default	33	2	94,3
		default	1	29	96,7
	Overallpercentage				95,4
Pas 2	Risk Class	Non-default	33	2	94,3
		default	1	29	96,7
	Overallpercentage				95,4
a. La valeur de coupe est ,500					

Source: Prepared by the researcher based on SPSS software outputs

Table 6, which presents the classification matrix, demonstrates the model's robust ability to distinguish between Defaulted" and Non-defaultedinstitutions, with an overall correct classification rate of 95.4%, reflecting the predictive power of the selected independent variables.

For the non-default institutions, out of 35 actual non-default institutions, the model correctly classified 33 and misclassified only 2, yielding a specificity rate94.3%. As for defaulted institutions, out of 30 actual defaulted institutions, the model correctly classified 29 and misclassified only one, this results in a sensitivity of 96.7% for this category.".

V. Results and discussion :

In light of the findings of the empirical study, which included statistical analysis using the logistic regression model and an evaluation of the Cagex-Rating model's effectiveness, the results of the hypothesis testing can be presented as follows:

- **Hypothesis 1:** The Cagex-Rating model relies on the integration of financial and qualitative indicators to achieve a comprehensive assessment of institutional risks, which was confirmed by the results of the model parameter estimation matrix in its second phase, showing that the model is stable on three qualitative variables with high statistical significance, as follows: credit history, management efficiency, and business diversification. This confirms the acceptance of the hypothesis, as the integration of qualitative variables with financial indicators grants the model explanatory power and a sound assessment of creditworthiness, thereby surpassing traditional financial analysis. This result aligns with the study by (TLIBA, 2012; Abdelkader GLIZ), which discusses the issue of the ineffectiveness of financial variables due to the informal economy in Algeria, including the earnings variable. The study emphasizes that Algerian banks compensate for this shortcoming by using reliable information obtained from the company's external environment, such as business volume and tax status, which improves credit risk assessment. This is what we emphasize by incorporating qualitative variables into the credit risk assessment process.
- **Hypothesis 2**: The Cagex-Rating model demonstrates statistically significant discriminatory power in predicting the probability of default for the institutions under study. The results of the rating matrix demonstrated the model's high efficiency, with an overall classification accuracy of 95.4%, a very high percentage indicating the model's ability to distinguish between sound and failing institutions with great precision. Furthermore, the results of the goodness-of-fit test reinforced this trend, as the significance level (Sig) in the second step was 0.854, which is much higher than the significance level (0.05). Statistically, this indicates acceptance of the null hypothesis, which states that there are no significant differences between the actual values and those predicted by the model. Consequently, the second hypothesis is accepted.
- **Third Hypothesis**: Our pilot evaluation of the Cagex-Rating model revealed a remarkable ability to distinguish between different types of credit risk. Specifically, the rating results achieved an overall accuracy of 95.4%, a notably high figure for this type of credit model. This level of accuracy indicates that the model ensures credit is directed toward the most creditworthy institutions, which necessarily leads to a reduction in the volume of non-performing loans. This demonstrates its reliability as a predictive tool for the Algerian banking sector.

VI. Conclusion:

In conclusion, the results of the statistical analysis showed that the Cagex-Rating model is highly effective in distinguishing between sound and defaulting firms, as evidenced by the Strong Goodness-of and classification accuracy rates exceeding 95%. These results highlight the important role played by qualitative variables—particularly credit history, management, and business diversification—as decisive factors in explaining the probability of default in the Algerian banking sector. Conversely, the study revealed the limited predictive role of quantitative variables (financial ratios), primarily due to the fragility of prevailing accounting and regulatory frameworks. Consequently, it is imperative for Algerian banks to adopt local internal models suited to local conditions, such as the Cagex-Rating model, while initially working to simplify these models by incorporating a set of quantitative and qualitative variables that can be accurately measured. This approach is likely to contribute to improving credit risk management mechanisms and reducing the volume of non-performing loans, thereby ensuring gradual compliance with the international requirements of the Basel Accords.

VII-Recommendations:

Based on the results obtained in this study, we present a number of recommendations aimed at improving risk measurement systems in the Algerian banking sector*:*

- Adopt local models such as the CAGEX Rating model, which will allow for the incorporation of qualitative variables alongside those of traditional financial analysis, thereby enhancing banks' ability to make more accurate lending decisions.

- Algerian banks can use this model to assess institutional risks with greater accuracy and reduce the risk of non-performing loans

- Developing credit databases: Since credit history was the strongest predictor of default, it is essential to enhance information sharing between Algerian banks and the Risk Center to feed the models with accurate and up-to-date data.

- Investing in qualitative analysis of institutions: We recommend training credit analysts to assess "management quality" and "business diversification plans," as the study demonstrated that these act as "protective shields" that reduce default risk by more than 95%.

- Periodic review of the model: It is essential to conduct periodic reviews of the quality of the models in use, as economic changes inevitably affect their continued predictive accuracy.

It should be noted that setting the sample size at 65 firms was constrained by a number of field difficulties, most notably the confidential nature of banking and financial data in Algeria, and the difficulty of obtaining complete time series for defaulting firms. Nevertheless, achieving a 95% accuracy rate using this sectorally diverse sample is a strong indicator of the model's statistical validity and its high generalizability despite the limitations related to the volume of available data.

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