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RESEARCH ARTICLE

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Corporate governance impact on banking risk

Abstract This study aims to determine the relationship between several factors of governance and the level of risk in 10 Tunisian banks during an analysis period of eight years. We propose an important empirical question and examine the internal mechanisms of governance aimed at reducing financial risks. This estimation is based on a model with a single equation that examines variables relative to governance and credit risk to determine their impact on banking financials. Results demonstrate that the internal mechanisms of governance present diverging effects on the financial risk of the Tunisian banks in our case study (i.e., credit risk). Moreover, making applications work by putting together a process and model for banking risk is important. This model can be applied in any bank, and the results can be used to make decisions in real time.

Keywords bank governance, banking risk, process decision, modeling, architecture

1 Introduction

Financial liberalization of the global economy engenders financial crises, financial instability of the banking industry, and appearance of financial risks. The banking sector has been severely criticized for its role in the recent financial crisis. Furthermore, the weak governance of banks is frequently identified as a major cause of the crisis (Kirkpatrick, 2009).

In this study, the mechanisms of bank governance, which aim to decrease banking crises, have garnered interest. In the banking sector, the problem of governance is more complicated than in other sectors. Banks occupy a very important role and establish a main component in any state economy.

Financial institutions, including banks, are involved in corporate governance. Banks are characterized by distinct agency problems and are more accented compared with other non-regulated firms. Many researchers have studied issues on banks' corporate governance in several countries (Levin, 2004; Laeven and Valencia, 2013). Adams and Mehran (2003) and Mehran and Mollineaux (2012) examined it from a US perspective. Ferrarini and Scaramozzino (2015) examined it from a European perspective. Hopt (2013) examined it from an international perspective. Banks have unique features that influence and interact with corporate governance mechanisms. Conflicts of interest between shareholders and debtholders, bank regulation, opacity, and complexity of bank activities are the main features that make bank governance different from that of nonfinancial companies (Fama, 1985).

A case in point is the financial crisis that started in 2008. The vulnerability of the banking sector during the crisis was at least in part caused by a build-up of excessive risks taken by some banks before the crisis (DeYoung and Torna, 2013). Thus, the extent to which governance failures have contributed to the risk exposures of banks has undergone significant discussion.

The objective of this research is to theoretically and empirically analyze the impact of internal governance mechanisms on Tunisian banks' risk-taking. Indeed, the central problem of this work is to predict banking risk before the risk materializes. This prediction is easy to detect after applying the model developed by the application of our work. Accordingly, the main focus of this work is to generate a global model and generic process to represent all relations between corporate governance and banking risk. Applying the model for any bank can help managers and stakeholders make decisions in real time.

This research is based on a sample of 10 Tunisian banks that are listed on Tunis Stock Exchange during an analysis

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period of 8 years.

In this work, we lead a study elaborated within the framework of the Tunisian banking sector. We base ourselves on the searches handled within corporate governance. We propose several control mechanisms to limit the conflicts of an agency within financial institutions and reduce excessive banking risks.

In Section 2, we illustrate several important previous works on banking risk. In Section 3, we define all selected variables impacting governance. In Section 4, we present the banking risk model and its details to show its importance. In Section 5, we propose the banking risk process and generic architecture to be applied on any bank. In Section 6, we present and analyze the experimental results for banking risk using tables for each bank.

2 Literature review

Hermalin and Weisbach (2001) showed that the board of directors is an economic institution, with a mission to reduce the problems between shareholders and leaders in agencies. Several empirical studies have assessed the impact of the size of the board of directors on the efficiency of its function (Jensen, 1993; Yermack, 1997). These studies recommend, for the most part, avoiding a large number of administrators.

Another characteristic that influences the efficiency of the control exercised by the administrators within the board of directors is the functions of decision and control. According to Brickley et al. (1997), duality means the allocation of the same person over the same period in both posts as managing director and chairman of the board.

Institutional investors are supposed to play an active role in the governance of banks. These particular shareholders represent influential partners for the banks. Their important financial means allow them to be very active investors in the control of the managers (Agrawal et al., 1992; Whidbee, 1997).

Khediri (2006) supposes that the advice of an important proportion of external administrators has a high probability of risk coverage. In addition, several studies (Dahya et al., 2008; Lefort and Urzúa, 2008; Salhi and Boujelbene, 2012) agree that foreigners' presence maximizes the wealth of the shareholders and assures the sustainability of the company because of their skills and experience in company services. The independence of the administrators is crucial for the council to have an effective follow-up mechanism (Brown, 2011).

Beltratti and Stulz (2012) analyzed the influence of corporate governance on banking risk during the crisis at the credit level. They proved that, in banks with a high number of shareholders in their boards, the corporate governance coefficient obtained from the risk metrics recorded a descendant evolution during the crisis. This finding indicates that the general understanding of "good governance" must not be regarded to have a direct connection with the shareholders' interest.

Cornett et al. (2009) examined the relationship between different corporate governance mechanisms and banking risks and elaborated a study on a sample of 300 banks from the USA. They posited that a positive association exists between a good corporate governance appreciated by the independence of the members of supervisory boards and the financial risk of banks.

Pearl-Kumah et al. (2014) examined the degree to which banks in Ghana use risk management practices and corporate governance in dealing with different types of risk. The results of the study indicated that the board of directors is actively involved in risk management and the most important types of risk faced by the sampled banks are credit, operating, and liquidity risks.

The boards' size is responsible for the identification, assessment, and management of all types of risks, including operational, market, and liquidity risks (Council FR, 2010). The debate regarding this relationship, which has long been ignored as an essential element in the process of bank development, minimizes the risk of the investors. Other researchers, such as Jensen (1993), indicated that a smaller board is more efficient in its controlling function, whereas a larger one tends to give the control of power to the CEO. In this context, Minton et al. (2011) found that the board's size negatively affects the market risk. Similarly, in a recent study, Kryvko and Reichling (2012) examined European banks and found a negative nexus between the board's size and the risk of the company. Another reasonable clarification provided by Kirkpatrick (2009) show that poor boards bear a culture of avarice and excessive remuneration, which drive financial executives to take risks that eventually cause financial crises.

Furthermore, several studies on the classification score and decision-making system have been recently developed (Jemmali et al., 2018; Melhim et al., 2018).

3 Variables impacting banking risk

To measure the risk of bank system, several variables need to be determined:

- *C* (concentration of capital): measured by the percentage of equity held by the largest shareholder.
- *PI* (percentage of capital held by institutional investors): the number of shares held by institutional investors/total number of shares.
- *PE* (percentage of capital held by foreign investors): the number of shares held by foreign investors/total number of shares.
- *P* (percentage of capital held by the state): number of shares held by the state/total shares.

- T (size of board): number of directors on the board.
- A (percentage of independent directors): number of independent directors/total directors in the boards.
- AI (percentage of institutional administrators): number of institutional administrators/total number of directors on the board.
- D (separation of CEO and chairman): takes the value of 1 if the CEO himself is the chairman of the board and 0 otherwise.

This model is denoted by the econometric model (EM). This model is created and tested after regressions of several variables.

For each variable, the EM gives an appropriate threshold value, denoted as TS.

- $TS(C)$: threshold of variable C. This value determines the field of C variable values impacting the banking risk. This is derived by calculating the percentage of equity held by the largest shareholder.
- $TS(PI)$: threshold of variable PI. This threshold can help make decisions for banking risk by evaluating the number of shares held by institutional investors.
- $TS(PE)$: threshold of variable PE. This value determines the field of PE variable values impacting the banking risk. This is derived by calculating the percentage of shares held by foreign investors.
- $TS(P)$: threshold of variable P. This value can impact banking risk by determining the critical number of shares held by the state.
- $TS(T)$: threshold of variable T. To calculate this value, the values of the maximum number of directors on the board should be known.
- $TS(A)$: threshold of variable A. The number of independent directors can impact the decision-making process of the board. Therefore, the percentage of participation in the board should be known. The threshold can be the limited value above it when its impact on decisions increases.
- $TS(AI)$: threshold of variable AI. This value is the maximum number of institutional administrators that can participate in the board.
- $TS(D)$: threshold of variable D. Variable D is a Boolean data type. Therefore, this variable can have only two values: 0 or 1. Accordingly, the threshold has also only two values: 0 or 1. This variable takes the value of 1 if the CEO himself is the chairman of the board and 0 otherwise.

4 Banking risk model

4.1 Evaluation of function $E(\,)$

Banking risk fundamentally depends on all variables previously described: C, PI, PE, P, T, A, AI, and D. For each variable, the EM gives an evaluation in the interval [0–10]. The evaluation given by EM uses function $E(\,)$. After using some regressions in econometrics, we can define two values. The first value is the lower bound of all values of the chosen variable (X). The second value is the upper bound of the chosen variable (X). We denote these values as LB (lower bound) and UB (upper bound).

Function $E(\,)$ can be calculated through different methods. In this work, we proposed two methods to evaluate function $E(\,)$:

1) Evaluation without $TS(\,)$ consideration;
2) Evaluation with $TS(\,)$ consideration:
   - Linear evaluation,
   - Evaluation based on classification.

4.1.1 Evaluation without $TS(\,)$ consideration

To calculate the value given by function $E(\,)$ for variable X, which has a value between LB and UB, we apply the evaluation without $TS(\,)$ consideration and calculate $E(X)$ as follows:

$$E(X) = X \times \frac{E(UB)}{UB}. \tag{1}$$

Propriety

Function $E(\,)$ has the following proprieties:

1) $E(X) = 0$, if $X = 0$.
2) $E(UB) = 10$.
3) $E(LB) = 1$, if $LB = 1$ and $UB = 10$.

Example 1

Let the chosen variable be C. For the selected case of 10 Tunisian banks, the number of values for each variable is 80. The minimum value among 80 is 5.61 and the maximum is 66.22, as shown in following figure:

In Fig. 1, the value of variable C is 18.11. This value is the concentration of capital for bank “BT” in 2006. Figure 2 shows the placement of 18.11 between bounds:

By applying Eq. 1, $E(18.11) = 18.11 \times \dfrac{10}{66.22} = 2.73$.

Remark

For variable D, EM gives two values: 0 or 10. Therefore, if $D = 1$, then $E(D) = 0$; otherwise, $E(D) = 10$.

4.1.2 Evaluation with $TS(\,)$ consideration

In the linear evaluation detailed previously, we do not consider any value of $TS(\,)$ introduced in the beginning of our paper. However, in practice and in several cases of banks, the values of different variables can be dispersed very largely. In this case, the $TS(\,)$ value should be introduced.

Thus, $TS(\,)$ is not necessarily placed in the middle of interval [LB, UB]. The consideration of thresholds makes the model more significant to have a real result for decisions.

In general, the $TS(\,)$ of any variable can be evaluated by managers or directors to guarantee the inclusion of values in the trusting interval. Indeed, the trusting interval is

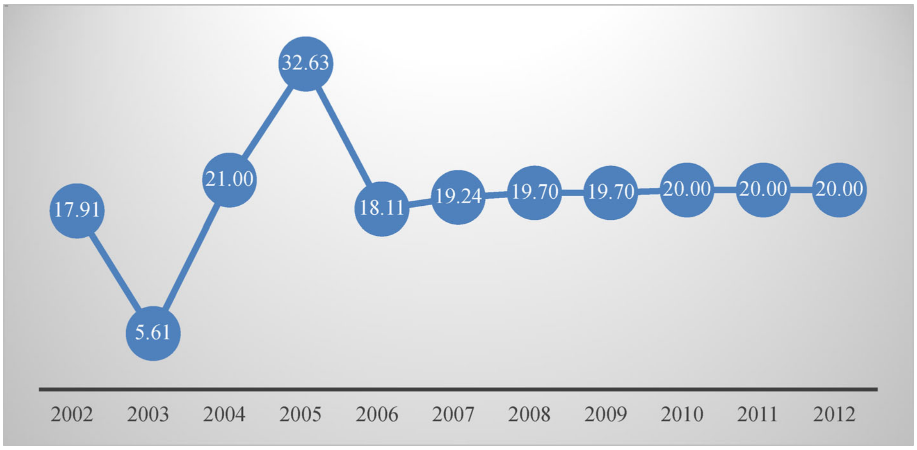

Fig. 1 Variation of C between 2002 and 2012.

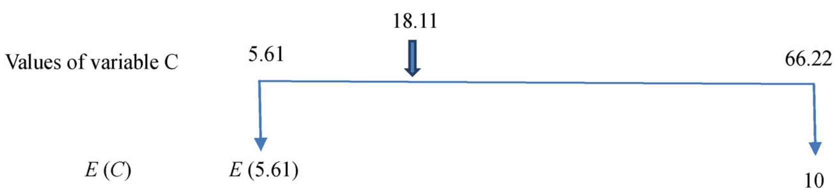

Fig. 2 Evaluation function for variable C.

determined by $[TS(X), UB]$.

Therefore, the consideration of thresholds in the formula to evaluate $E(\,)$ has great significance.

This evaluation depends on the distance between the value of the variable and its $TS(\,)$.

We consider the two bounds described in the previous method (LB and UB) and let X be the chosen independent variable.

Figure 3 shows the trusting interval:

In the figure, the value of variable X does not satisfy the manager's needs because $X < TS(X)$.

We propose two methods to evaluate $E(\,)$ as detailed below.

a) Linear evaluation

On the basis of Fig. 3, we propose the following linear method to calculate the value of $E(X)$ for variable X:

$$E(X) = \begin{cases} X \times \dfrac{E\left(TS(X)\right)}{TS(X)}, \text{ if } X < TS(X), \\ X \times \dfrac{E(UB)}{UB}, \text{ otherwise.} \end{cases} \tag{2}$$

Propriety

Function $E(\,)$ has the following proprieties:

1) $E(X) = 0$, if $X = 0$.
2) $E(UB) = 10$.
3) $E(LB) = 1$, if $LB = 1$ and $UB = 10$.
4) $E(T)\,S(X) = 5$.

Example 2

Let the chosen variable be C, which has the same values in example 1. Let $TS(C) = 60$.

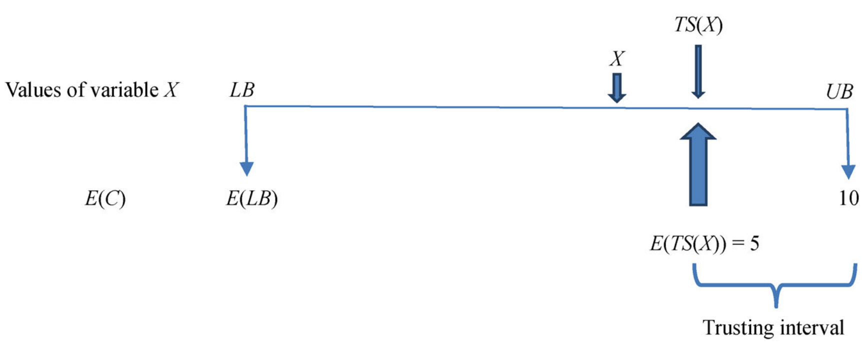

Fig. 3 Trusting interval.

$C = 18.11$. Applying Eq. 2, $C < TS(C)$ then $E(18.11) = 18.11 \times \dfrac{E(TS(X))}{TS(X)} = 18.11 \times \dfrac{5}{60} = 1.5$.

Comparing the evaluation without $TS(\ )$ consideration, the value given by $E(\ )$ is 2.73. This example shows that the evaluation of variable C is decreasing. This decrease is attributed to the greater value of $TS(X)$ chosen by the manager.

Then, we choose $C = 62$ and apply Eq. (2): $C > TS(C)$ then $E(62) = 62 \times \dfrac{E(UB)}{UB} = 62 \times \dfrac{10}{66.22} = 9.36$.

b) Evaluation based on classification

This method is simple to apply and is based on a classification made by dividing the values of variables into two interval ranges. The first interval includes all values smaller than $TS(\ )$, and the second interval includes all values greater than or equal to $TS(\ )$.

The first interval does not include the trusting interval. Thus, we call this interval "Not satisfied clusters" (NSC). Moreover, the second interval is called "Satisfied clusters" (SC).

For the NSC group:

All values are between $[LB,\ TS(X)]$. The value of $E(TS(X)) = 5$; therefore, we propose dividing the interval $[LB,\ TS(X)]$ into five subintervals.

Let $S_1 = \dfrac{TS(X) - LB}{5}$. Based on the value of S_1, we propose the following subintervals:

$$P_i^{\mathrm{NSC}} = [LB + (i-1) \times S_1,\ LB + i \times S_1], \text{ with } 1 \leqslant i \leqslant 5.$$

To calculate the value of $E(X)$, we propose the following classifications:

1) If $X \in P_1^{\mathrm{NSC}}$, then $(X) = 0.5$.
2) If $X \in P_2^{\mathrm{NSC}}$, then $(X) = 1$.
3) If $X \in P_3^{\mathrm{NSC}}$, then $(X) = 2$.
4) If $X \in P_4^{\mathrm{NSC}}$, then $(X) = 3$.
5) If $X \in P_5^{\mathrm{NSC}}$, then $(X) = 4.5$.

For the SC group:

All values are between $[TS(X),\ UB]$. We propose to divide the interval $[TS(X),\ UB]$ into five subintervals.

Let $S_2 = \dfrac{UB - TS(X)}{S}$. On the basis of the value of S_2, we propose the following subintervals:

$$P_i^{\mathrm{SC}} = [TS(X) + (i-1) \times S_2,\ TS(X) + i \times S_2],$$

$$\text{with } 1 \leqslant i \leqslant 5.$$

To calculate the value of $E(X)$, we propose the following classifications:

1) If $X \in P_1^{\mathrm{SC}}$, then $(X) = 5$.
2) If $X \in P_2^{\mathrm{SC}}$, then $(X) = 6$.
3) If $X \in P_3^{\mathrm{SC}}$, then $(X) = 7$.
4) If $X \in P_4^{\mathrm{SC}}$, then $(X) = 8$.
5) If $X \in P_5^{\mathrm{SC}}$, then $(X) = 9$.

Example 3

Let the chosen variable be C which has the same values as in example 1. Let $TS(C) = 60$.

1) $C = 18.11$. The previous evaluation based on classification shows that the value of C is smaller than $TS(C)$. Then, C is in the NSC group. Accordingly, S_1 is calculated below:

$$S_1 = \frac{TS(X) - LB}{5} = \frac{60 - 5.61}{5} = 10.87.$$

The position of C in the five subintervals is searched and the equation

$$p_i^{\mathrm{NSC}} = [LB + (i-1) \times S_1,\ LB + i \times S_1], \text{ with } 1 \leqslant i \leqslant 5$$

is applied.

$$P_1^{\mathrm{NSC}} = [LB + (1-1) \times S_1,\ LB + 1 \times S_1]$$

$$= [5.61,\ 5.61 + 10.87] = [5.61,\ 16.48].$$

C is not in P_1^{NSC}. Next, we determine P_2^{NSC}:

$$P_2^{\mathrm{NSC}} = [LB + (2-1) \times S_1,\ LB + 2 \times S_1]$$

$$= [5.61 + 10.87,\ 5.61 + 2 \times 10.87]$$

$$= [16.48,\ 27.35].$$

$C \in P_2^{\mathrm{NSC}}$, so $E(C) = 1$

2) $C = 62$: The previous evaluation based on classification shows that the value of C is greater than $TS(C)$. Then, C is in the SC group. Accordingly, S_2 is calculated below:

$$S_2 = \frac{UB - TS(X)}{5} = \frac{66.22 - 60}{5} = 1.24.$$

Then, we can search the position of C in the five subintervals by applying

$$P_i^{\mathrm{SC}} = [TS(X) + (i-1) \times S_2,\ TS(X) + i \times S_2],$$

$$\text{with } 1 \leqslant i \leqslant 5.$$

$$P_1^{\mathrm{SC}} = [TS(X) + (1-1) \times S_2,\ TS(X) + 1 \times S_2]$$

$$= [60,\ 60 + 1.24] = [60,\ 61.24].$$

$C \in P_1^{\mathrm{SC}}$. Next, we determine P_2^{SC}:

$$P_2^{\mathrm{SC}} = [TS(X) + (2-1) \times S_2,\ TS(X) + 2 \times S_2]$$

$$= [61.24,\ 60 + 2 \times 1.24] = [60,\ 62.48].$$

Therefore, $C \in P_2^{\mathrm{SC}} \ \rightarrow\ E(C) = 6$.

4.2 Weight evaluation

Each variable has different impacts. Therefore, each variable should be given a weight related to its impact on the banking risk.

We denote weight by w_i^j, where i is the independent variable and j is the dependent variable.

$$Y_{it} = \alpha + \sum_{j=1}^{n} \beta_j X_{it} + \varepsilon_{it}, \tag{3}$$

with

Y_{it}: the measure of bank risk i at time t;

Y_{it}: three risk measures, namely, Y_1, Y_2, and Y_3;

α: a constant term;

ε_{it}: the error term (white noise residual);

X_{it}: the group of explanatory variables, which includes the ownership structure and board of directors.

The equation becomes $y_{it} = \alpha + \beta_1 C + \beta_2 PI + \beta_3 PE + \beta_4 P + \beta_5 T + \beta_6 A + \beta_7 AI + \beta_8 D$.

After applying regressions using EViews 7, all t-student values are provided as Table 1:

Table 1 Regression results (NB: robust statistics; Student (t) are shown in brackets)

Variables	Y_1	Y_2	Y_3
α	69.94585 (1.083473)	−2.556103 (−4.265473)	9.423792 (2.280047)
C	−0.234045 (−2.220154)	0.000590 (0.331404)	0.012095 (0.984907)
PI	−0.153396 (−0.760449)	0.001646 (0.879028)	3.047509 (2.039424)
PE	−0.199973 (−2.197709)	0.000965 (0.622772)	−0.003969 (−0.371303)
P	−0.111681 (−0.769758)	0.001107 (3.821606)	−0.004986 (−0.536751)
T	−1.023996 (−1.054921)	0.020733 (2.300960)	0.034649 (0.557538)
A	−51.03836 (−3.828917)	−0.094628 (−0.764773)	0.344336 (0.403481)
AI	12.72056 (0.503413)	0.343575 (2.464778)	−0.840338 (−0.519439)
D	1.376378 (0.244547)	0.172884 (3.309116)	−0.036064 (−0.100082)
$R2$	0.460311	0.626092	0.330560
Observations	80	80	80

Note: The weight of each variable is exactly the t-student value given by modeling with regression.

4.3 Modeling

The risk in the banking sector is characterized by a multidimensional and multiplicity nature.

The evaluation of the banking risk was essentially based on three dependent variables. The overall risk is measured by the standard deviation of the ratio of return on assets (Y_1). In addition, the ratio of provisions over the total credit (Y_2) was used. The standard deviation of return notes on the equity (Y_3). The value of Y_j is calculated as

$$Y_j = \sum_{i=1}^{n} X_i \times w_1^j, \tag{4}$$

with

$$X_i = \begin{cases} -E(X), & \text{if } t\_student\ X > 0, \\ +E(X), & \text{if } t\_student\ X > 0. \end{cases}$$

Then, we calculate the banking risk for each dependent variable defined above (Y_1, Y_2, and Y_3).

The banking risk for dependent variable j is denoted as BR_j.

After calculating each banking risk, the global risk BR can be assumed in the global variable, which is based on BR_j:

$$BR = \frac{\sum_{j=1}^{3} BR_j}{3}. \tag{5}$$

To make decisions based on the value given by Eq. (5), we propose the following banking risk ranges.

We can use Table 2 as a reference to make classifications in all levels of banking risk.

Table 2 Banking risk range

Risk description	BR
Good bank trusting	[0–15]
Bank that we can trust	[16–25]
Bank that has a little bit of risk	[26–35]
Bank that is uncertain to fail	[36–45]
Bank with risk to fail	[45–60]
Bank that can fail	[61–70]
Bank with failure assumption	[71–80]
Failed bank	[81–100]

Propriety

The value of variable BR can be positive or negative.

$$BR \begin{cases} > 0, & \text{the decision can be made by referencing to Table 2,} \\ \leqslant 0, & \text{no rise: we cannot judge the bank with Table 2.} \end{cases}$$

Proposition

$$BR_j = \left(\frac{Y_j}{\sum_{i=1}^{8} w_i^j} \right) \times z, \text{ with } z = 10. \tag{6}$$

Proof

The parameter z cited in Eq. (6) is derived from the following example.

Let all values provided by $E(\,)$ for all variables equal to

10. Thus, $E(X) = UB = 10, \forall X \in V$ with V as the set of all variables.

In this case, $Y_j = 10 \times \sum_{i=1}^{8} w_i^j$.

For this example, setting BR_j to 100 is imperative as $E(\,)$ is obtained for the UB value.

$$BR_j = \left(\frac{Y_j}{\sum_{i=1}^{8} w_i^j}\right) \times z = 100 => z = \frac{\sum_{i=1}^{8} w_i^j}{Y_j} \times 100$$

$$= \frac{\sum_{i=1}^{8} w_i^j}{10 \times \sum_{i=1}^{8} w_i^j} \times 100 = 10.$$

Example 4

Using a real example from our life is a better way to understand the model and how to calculate the risk. For this example, we choose the "Banque de Tunisie" for the year 2006. The values of all variables are given in Table 3:

Table 3 Values of independent variables for TB in 2006

Bank	Year	C	PI	PE	P	T	A	AI	D
BT	2006	18.11	45.26	0	45.26	17	0.41	0.18	1

For this example, EM gives the value of 2.73. Thus, the evaluation of variable C is completed. The EM evaluates all remaining variables using the same evaluation of C. Accordingly, the remaining variables are evaluated by the following equations:

$$E(PI) = 45.26 \times \frac{10}{99.61} = 4.54,$$

$$E(PE) = 0 \times \frac{10}{76.65} = 0,$$

$$E(P) = 45.26 \times \frac{10}{68.2} = 6.63,$$

$$E(T) = 17 \times \frac{10}{17} = 10,$$

$$E(A) = 0.41 \times \frac{10}{0.81} = 5.06,$$

$$E(AI) = 0.18 \times \frac{10}{0.4} = 4.5,$$

$$E(D) = 1 \times \frac{10}{1} = 10.$$

Y_1: let the weight values:

$$w_1^1 = 2.22,\ w_2^1 = 0.76,\ w_3^1 = 2.19,\ w_4^1 = 0.76,$$

$$w_5^1 = 1.05,\ w_6^1 = 3.82,\ w_7^1 = 0.5,\ w_8^1 = 0.24.$$

$$BR_1 = \left(\frac{-6.06-3.45-0-5.04-10.5-19.33+2.25+2.4}{11.54}\right) \times 10 = -34.42.$$

Y_2: let the weight values:

$$w_1^2 = 0.33,\ w_2^2 = 0.87,\ w_3^2 = 0.62,\ w_4^2 = 3.82,$$

$$w_5^2 = 2.3,\ w_6^2 = 0.76,\ w_7^2 = 2.46,\ w_8^2 = 3.3.$$

$$BR_2 = \left(\frac{0.9+3.95+0+25.35+23-3.84+11.7+33}{14.46}\right) \times 10 = 65.04.$$

Y_3: let the weight values:

$$w_1^3 = 0.98,\ w_2^3 = 2.03,\ w_3^3 = 0.37,\ w_4^3 = 0.53,$$

$$w_5^3 = 0.55,\ w_6^3 = 0.4,\ w_7^3 = 0.51,\ w_8^3 = 0.1.$$

$$BR_3 = \left(\frac{2.67+9.22-0-3.51+5.+2.02-2.29-1}{5.47}\right) \times 10 = 23.05.$$

$$BR = \frac{\sum_{j=1}^{3} BR_j}{3} = \frac{-34.42+65.04+23.05}{3} = 17.98.$$

The bank description in Table 2 is "Bank that we can trust."

5 Banking risk process

5.1 Process

In this section, we present a model and method chosen to calculate scores and make rankings to help any bank make decisions. We present processes to help users of the system make decisions easily. The process can offer users an efficient description of several choices by applying the model described above. The process describes all steps from start (user preference) to finish (decision). The user can input preferences and the system will apply the process to give the decisions to the user automatically.

The intelligent system used in this process applies all methods. It describes the model given by the regression and analysis statistics using "t-student" scores in an architecture. Therefore, managers and directors can use the process to find decisions given by the system automatically. The process is composed of the following: user preference, independent variable selector, dependent variable selector, EM, thresholder, DB, sources, range results, request to search data, weight, calculators (BR_j and BR), risk, and decision.

In Fig. 4, we denote:

1) n: the number of total independent variables. In our case, $n = 8$.

2) i: the number of chosen independent variables.

3) j : the number of chosen dependent variables.

5.2 Description components

Our decision process is displayed in Fig. 4. The proposed process is based on several components. Each component has a specific meaning and can be explained by the following:

1) User preference: From this component, the user can insert and choose his preferences. The preferences of the user can be based on all interested points to make decisions on banking risk.

2) Independent variable selector: The user must choose the independent variable to calculate its value by applying the model and score ranking. Therefore, among eight variables, the user selects the first variable. Then, the user chooses, for instance, the second until all variables have been selected and affected.

3) Dependent variable selector: The user must choose the dependent variable to calculate its value by applying the model and score ranking. Therefore, among three variables, the user selects the first variable. Then, the user will choose, for instance, the second until all variables have been selected and affected.

4) EM: The EM and method to calculate t-student are saved and globed in the "EM" component. Thus, for the elaboration of all t-student values to be used in making weights, we must communicate with the "EM" component before modeling.

5) Thresholder: In the determination of the threshold value of each variable, the "Thresholder" component should be called upon. This component is responsible for evaluating all thresholds. The input of this component is based on the choice of variable, that is, the named variable. The output of this component is the threshold of the variable given in the input.

6) DB: All thresholds and weights are saved in one database.

7) Sources: To apply regressions and calculate t-student scores, the "EM" component must have some information. This required information is the input for the "EM" component. All information is stocked in the sources. The sources can be an Excel file or database. Files can contain some information that can be used in the modeling of the regression.

8) Range results: All responses of "EM" requests can be ranged in the "Range results" component to make it easier to use the information found in the research.

9) Request to search data: All demand and orders from "EM" components are stocked and derigged by the "Request to search data" component.

10) Weight: This component uses outputs of the "EM" component to evaluate the weight of variables chosen in the "Variable selector" component.

11) Function: To apply the model described in this work, we must apply the method to calculate the score and evaluate all values of the score. This evaluation is localized in the "Function" component. The input of this component is all weights and thresholds determined previously. The output of this component is the value of the score of the banking risk.

12) Calculator: BR_j: This component is based on the method chosen in our model to calculate BR_1, BR_2, *and* BR_3.

13) Calculator: BR: This component is based on the method chosen in our model to calculate BR.

14) Risk: After calculation, the value of BR is sent to the "Risk" component. This component saves the score (BR) and classifies the bank based on the banking risk range described in Table 2.

15) Decision: Decisions are set to managers and administrators of the system.

5.3 Walk-through process decision

Based on Fig. 4, we describe the following walk-through process to show how to use the decision system.

Step 1: The user chooses preferences.

Step 2: The user chooses dependent variables (choose j).

Step 3: The user chooses independent variables (choose i).

Step 4: After choosing the variable, the "EM" sends requests to sources. The range of the results will be sent to "EM."

Step 5: All t-student values will be saved in "thresholder."

Step 6: All weights will be evaluated by "weight."

Step 7: A mandatory test occurs to verify if the number of independent variable is less than n.

If $i < n$, then we move to Step 4 to pass to the next variable. We repeat the process until we finish all variables. Otherwise, we proceed to Step 8.

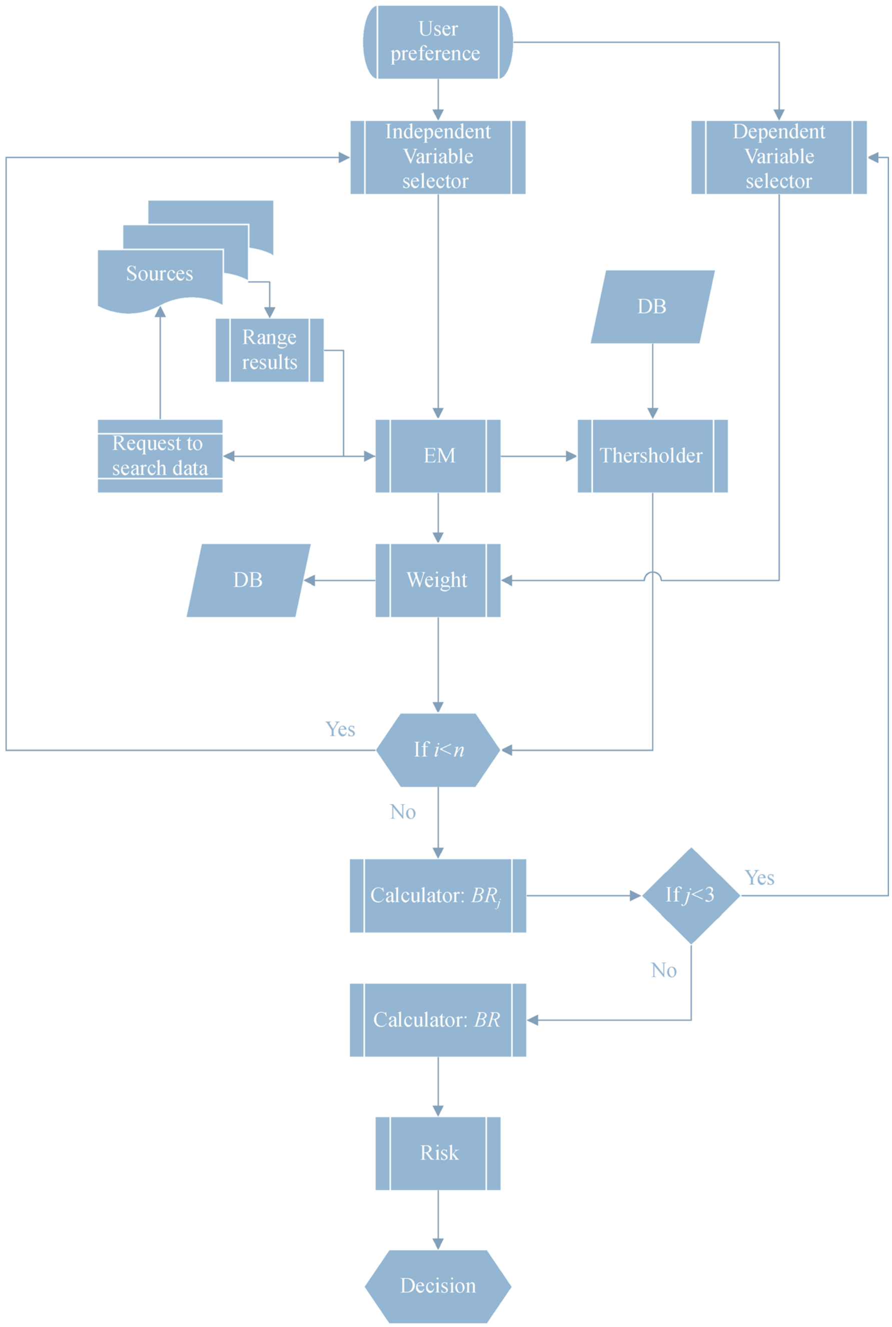

Fig. 4 Process decision.

Step 8: Now, we can calculate BR_j.

Step 9: Test if $j < 3$, and then move to Step 6 to the next dependent variable.

Step 10: Now, the calculation of *BR* will be completed.

Step 11: Decisions are ready to use.

6 Experimental results

The experimental results are based on 10-year data (2002–2012) of 10 Tunisian banks. The model explained in the previous section shows that, to make decision for any bank, we must calculate the score *BR*, which is based on the calculation of BR_1, BR_2, and BR_3. After the collection of eight values of independent variables from 10 banks, we calculate for each bank the value returned by function $E(\ )$ for each variable. In addition, in the following tables, we present all values of Y_1, Y_2, and Y_3 for each bank.

Therefore, from the value of *BR*, the decision can be made by referring to Table 2.

In Table 4, all values of *BR* are positive. Thus, all decisions can be made by referring to the table of range bank (Table 2).

The minimum value of *BR* for bank "BT" for 2003 is

6.89, which corresponds to the decision “Good bank trusting.” In 2003, this bank is the best one in terms of banking risk. By comparison, the maximum value of *BR* for 2006 is 17.74, which corresponds to the decision “Bank that we can trust.”

Table 5 shows that all values of *BR* are positive. This result means that all decisions can be made by referring to Table 2.

For “STB” bank, Table 6 shows that only three years are within the range of the decision “Good bank trusting.”

In Table 7, for 2006, the *BR* in “BH” bank is very small, but the next 3 years contain the greatest values of *BR*. This phenomenon can convince managers to launch some studies to examine the cause of the increased risk.

Compared with the previous bank, the “BNA” bank shown in Table 8 has the first range “Good bank trusting” in Table 2 for 10 years.

For the “UIB” bank illustrated in Table 9, the bank passed the second range in Table 2, that is, “Bank that we can trust,” only in 2004. In addition, between 2006 and 2012, all its values are less than 4. Thus, the bank is in the best situation in terms of risk.

For “UBCI” bank illustrated in Table 10, all values of *BR* are in the first interval of ranging decision from Table 2.

The year 2005 is the radical year for the “AB”, as shown in Table 11. From this year until 2012, all values of *BR* are decreasing, compared with the values in 2004.

As shown in Table 12, the “Attijari” bank has no risk from 2007 to 2012, so we cannot judge the bank in accordance with Table 2.

As shown in Table 13, the “ATB” bank has the same situation regarding risk as “AB” bank.

Figure 5 shows the best and worst years for the *BR* value of each bank. For “BT” bank, the best year was 2003 and the worst year was 2006.

In general, based on the model that was detailed and

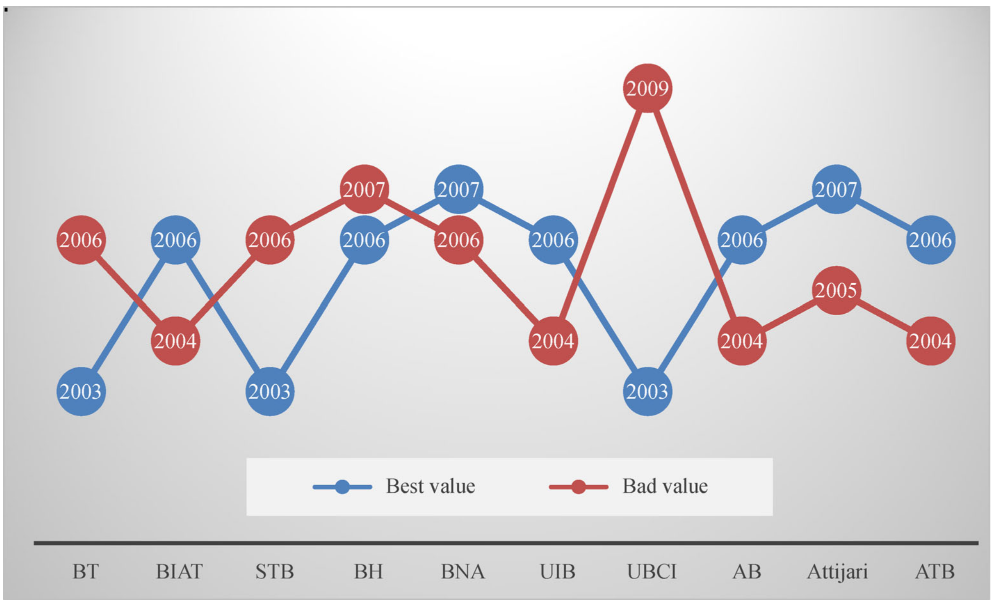

Fig. 5 Best and worst years for *BR* values.

Table 4 “BT” banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
BT	2002	2.70	3.13	3.03	0.00	5.29	4.07	2.75	10.00	−32.36	54.34	10.02	−28.04	37.58	18.33	9.29
	2003	0.85	5.23	3.68	0.03	10.00	3.58	3.00	0.00	−36.61	34.88	15.47	−31.72	24.12	28.28	6.89
	2004	3.17	5.07	1.44	6.74	8.82	5.80	1.75	10.00	−47.32	85.30	14.57	−41.00	58.99	26.63	14.87
	2005	4.93	4.94	0.03	7.21	5.88	6.17	5.00	10.00	−45.10	87.64	13.18	−39.08	60.61	24.09	15.20
	2006	2.73	4.54	0.00	6.64	10.00	5.06	4.50	10.00	−39.75	93.43	12.62	−34.45	64.61	23.06	17.74
	2007	2.91	4.43	3.54	1.62	5.29	2.72	2.75	10.00	−30.96	63.06	11.27	−26.83	43.61	20.61	12.46
	2008	2.97	4.43	2.98	0.00	4.12	1.73	7.00	10.00	−21.52	65.07	9.18	−18.65	45.00	16.78	14.38
	2009	2.97	4.43	2.98	0.00	4.12	1.73	7.00	10.00	−21.52	65.07	9.18	−18.65	45.00	16.78	14.38
	2010	3.02	4.57	2.80	0.00	3.53	2.10	7.00	10.00	−22.13	63.46	9.41	−19.17	43.89	17.20	13.97
	2011	3.02	4.54	2.97	0.00	3.53	2.10	7.00	10.00	−22.48	63.54	9.29	−19.48	43.94	16.99	13.82
	2012	3.02	4.88	3.01	0.00	4.71	1.54	7.00	10.00	−21.95	66.99	10.39	−19.02	46.33	19.00	15.44

Table 5 “BIAT” banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
BIAT	2002	3.78	8.06	6.80	2.89	5.88	8.64	10.00	10.00	−63.38	88.06	16.60	−54.93	60.90	30.36	12.11
	2003	7.55	5.02	6.63	0.00	5.88	1.23	5.00	10.00	−41.09	68.86	15.31	−35.61	47.62	28.00	13.34
	2004	4.01	5.55	0.03	0.00	7.06	4.07	6.25	10.00	−30.62	67.68	16.51	−26.53	46.81	30.18	16.82
	2005	2.03	4.00	2.03	3.20	7.06	7.16	2.00	10.00	−45.78	66.32	12.38	−39.67	45.87	22.64	9.61
	2006	9.70	7.80	8.38	0.02	7.06	6.17	2.00	0.00	−75.83	31.73	27.56	−65.71	21.94	50.38	2.20
	2007	6.86	7.38	3.64	0.02	7.06	3.09	4.00	0.00	−46.04	34.76	23.42	−39.89	24.04	42.82	8.99
	2008	7.13	7.44	3.10	0.02	7.06	3.09	4.00	0.00	−45.49	34.54	24.01	−39.42	23.89	43.89	9.45
	2009	8.78	7.56	2.24	0.01	7.06	3.09	4.00	0.00	−47.34	34.64	26.20	−41.02	23.96	47.89	10.28
	2010	8.61	7.48	1.03	0.01	4.71	1.60	7.50	0.00	−34.38	38.08	22.64	−29.79	26.34	41.39	12.65
	2011	8.78	7.27	1.01	0.01	5.29	2.72	5.00	0.00	−40.67	32.30	24.42	−35.24	22.34	44.65	10.58
	2010	10.00	7.43	1.03	0.01	5.29	2.72	5.00	0.00	−43.54	32.86	25.95	−37.73	22.72	47.44	10.81

Table 6 “STB” banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
STB	2002	3.01	3.13	3.22	0.00	5.29	4.07	2.75	10.00	-33.45	54.56	10.25	-28.98	37.73	18.74	9.16
	2003	0.85	5.23	3.20	0.03	10.00	3.58	3.00	0.00	−35.56	34.59	15.65	−30.81	23.92	28.60	7.24
	2004	3.17	5.07	1.44	6.74	9.41	5.43	1.50	10.00	−46.64	86.32	14.87	−40.42	59.69	27.18	15.49
	2005	4.93	4.94	0.40	7.21	5.88	6.17	5.00	10.00	−45.91	87.87	13.04	−39.78	60.77	23.84	14.94
	2006	2.73	4.54	0.00	6.64	10.00	5.06	4.50	10.00	−39.76	93.43	12.61	−34.46	64.61	23.06	17.74
	2007	7.93	7.28	1.09	7.70	7.06	9.26	6.25	10.00	−68.64	96.61	21.46	−59.48	66.81	39.24	15.52
	2008	7.93	7.35	1.08	7.70	7.06	9.26	6.25	10.00	−68.65	96.66	21.62	−59.49	66.85	39.52	15.63
	2009	7.93	7.12	1.18	7.70	7.06	9.26	6.25	10.00	−68.71	96.52	21.10	−59.54	66.75	38.58	15.26
	2010	7.96	7.15	1.30	7.73	7.06	9.26	6.25	10.00	−69.07	96.74	21.13	−59.85	66.90	38.63	15.23
	2011	7.96	7.26	1.24	7.73	7.06	9.26	6.25	10.00	−69.03	96.80	21.38	−59.82	66.94	39.08	15.40
	2012	7.96	7.29	1.27	7.73	7.06	9.26	6.25	10.00	−69.11	96.84	21.43	−59.89	66.97	39.18	15.42

Table 7 “BH” banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
BH	2002	7.85	8.06	6.80	0.00	6.47	2.22	9.25	0.00	−49.11	49.77	21.27	−42.56	34.42	38.88	10.25
	2003	7.55	5.02	6.63	0.00	5.88	1.23	5.00	10.00	−41.09	68.86	15.31	−35.61	47.62	28.00	13.34
	2004	4.01	5.55	0.03	0.00	7.06	4.07	6.25	10.00	−30.62	67.68	16.51	−26.53	46.81	30.18	16.82
	2005	2.03	4.00	2.23	3.20	7.06	7.16	2.00	10.00	−46.21	66.44	12.31	−40.04	45.95	22.51	9.47
	2006	9.70	7.80	8.38	0.00	7.06	6.17	2.00	0.00	−75.81	31.65	27.57	−65.69	21.89	50.40	2.20
	2007	8.78	10.00	2.30	8.52	6.47	7.78	9.00	10.00	−68.19	109.68	24.61	−59.09	75.85	45.00	20.59
	2008	8.78	10.00	2.30	8.52	6.47	7.78	9.00	10.00	−68.19	109.68	24.61	−59.09	75.85	45.00	20.59
	2009	8.78	10.00	2.30	8.52	6.47	7.78	9.00	10.00	−68.19	109.68	24.61	−59.09	75.85	45.00	20.59
	2010	8.64	7.53	1.34	8.39	8.24	8.64	7.00	10.00	−69.98	104.88	22.24	−60.65	72.53	40.65	17.51
	2011	8.48	7.65	1.05	8.23	6.47	7.78	9.00	10.00	−62.79	105.65	20.17	−54.41	73.07	36.87	18.51
	2012	8.61	7.73	1.27	8.36	6.47	7.78	9.00	10.00	−63.72	106.40	20.32	−55.22	73.58	37.14	18.50

Table 8 "BNA" banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
BNA	2002	3.01	3.34	3.40	0.00	5.29	2.72	2.75	10.00	−28.82	55.88	10.05	−24.98	38.65	18.38	10.68
	2003	1.36	5.23	3.57	0.03	10.00	3.58	3.00	0.00	−37.51	34.99	16.01	−32.51	24.20	29.27	6.99
	2004	3.78	5.07	1.43	6.89	7.06	7.16	2.00	10.00	−51.97	81.58	14.53	−45.03	56.42	26.56	12.65
	2005	4.93	4.94	0.84	7.21	5.88	6.17	2.50	10.00	−48.13	81.99	14.15	−41.70	56.70	25.86	13.62
	2006	2.73	4.54	0.01	6.64	7.06	7.16	4.25	10.00	−44.84	84.46	11.96	−38.86	58.41	21.87	13.81
	2007	2.73	4.54	0.01	6.64	6.47	7.78	4.50	0.00	−48.85	50.26	12.76	−42.34	34.76	23.32	5.25
	2008	2.73	6.92	0.02	9.79	6.47	7.78	4.50	0.00	−53.07	64.37	15.90	−45.99	44.51	29.06	9.20
	2009	3.55	7.08	0.02	9.70	6.47	7.78	4.50	0.00	−54.93	64.45	17.08	−47.60	44.57	31.23	9.40
	2010	4.02	6.48	0.02	10.00	6.47	7.78	4.50	0.00	−55.74	65.21	16.15	−48.30	45.10	29.52	8.77
	2011	4.02	6.49	0.02	9.84	6.47	7.78	4.50	0.00	−55.63	64.61	16.25	−48.20	44.68	29.71	8.73
	2012	4.02	6.55	0.02	9.81	6.47	7.78	4.50	0.00	−55.65	64.55	16.39	−48.23	44.64	29.97	8.79

Table 9 "UIB" banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
UIB	2002	7.85	8.06	6.80	0.00	7.06	2.10	8.25	0.00	−49.74	48.75	22.05	−43.11	33.71	40.32	10.31
	2003	7.55	5.02	6.63	0.00	5.88	1.23	5.00	10.00	−41.09	68.86	15.31	−35.61	47.62	28.00	13.34
	2004	4.00	5.56	0.03	0.00	7.06	4.07	6.25	10.00	−30.62	67.69	16.53	−26.53	46.81	30.21	16.83
	2005	2.03	4.00	2.23	3.20	7.06	7.16	2.00	10.00	−46.21	66.44	12.31	−40.04	45.95	22.51	9.47
	2006	9.70	7.80	8.38	0.00	7.06	6.17	2.00	0.00	−75.81	31.65	27.57	−65.69	21.89	50.40	2.20
	2007	9.70	8.04	8.38	0.00	7.06	6.17	2.00	0.00	−76.00	31.86	28.07	−65.85	22.03	51.31	2.50
	2008	9.70	8.41	8.38	0.00	7.06	6.17	2.00	0.00	−76.27	32.18	28.81	−66.10	22.25	52.67	2.94
	2009	9.70	8.80	8.38	0.00	7.06	6.17	2.00	0.00	−76.57	32.52	29.61	−66.35	22.49	54.13	3.42
	2010	9.70	8.84	8.38	0.00	7.06	6.17	2.00	0.00	−76.60	32.55	29.68	−66.38	22.51	54.25	3.46
	2011	9.70	8.84	8.38	0.00	7.06	6.17	2.00	0.00	−76.60	32.56	29.69	−66.38	22.51	54.28	3.47
	2012	9.70	8.83	8.38	0.00	7.06	6.17	2.00	0.00	−76.60	32.55	29.67	−66.37	22.51	54.24	3.46

Table 10 "UBCI" banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
UBCI	2002	3.02	3.34	3.46	0.00	5.29	2.72	2.75	10.00	−28.97	55.92	10.05	−25.11	38.67	18.37	10.64
	2003	2.85	6.81	4.31	0.00	7.06	4.07	4.25	0.00	−41.79	33.13	18.37	−36.21	22.91	33.58	6.76
	2004	3.75	5.07	1.30	7.70	7.06	8.27	2.00	10.00	−56.47	83.72	14.56	−48.93	57.90	26.63	11.86
	2005	4.93	4.94	1.24	7.21	6.47	6.67	2.25	10.00	−51.62	82.60	14.65	−44.73	57.12	26.78	13.06
	2006	2.73	4.54	0.02	6.22	7.06	7.16	4.25	10.00	−44.53	82.86	12.18	−38.59	57.31	22.27	13.66
	2007	7.55	8.52	6.52	0.00	4.12	5.93	6.00	10.00	−59.09	66.68	22.86	−51.20	46.11	41.80	12.24
	2008	7.55	8.89	6.52	0.00	4.12	3.46	3.50	10.00	−51.18	62.72	23.90	−44.35	43.38	43.69	14.24
	2009	7.55	9.26	6.52	0.00	4.12	3.46	3.50	10.00	−51.46	63.04	24.64	−44.59	43.60	45.04	14.68
	2010	1.56	8.95	6.52	0.00	8.24	4.07	5.00	0.00	−46.25	40.49	20.90	−40.08	28.00	38.21	8.71
	2011	1.56	8.92	6.52	0.00	8.24	4.07	5.00	0.00	−46.23	40.47	20.84	−40.06	27.99	38.09	8.67
	2012	1.56	9.04	6.52	0.00	8.24	4.07	5.00	0.00	−46.32	40.57	21.07	−40.14	28.05	38.51	8.81

Table 11 "AB" banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
AB	2002	7.90	8.11	6.83	0.00	6.47	2.22	9.00	0.00	−49.45	49.23	21.53	−42.85	34.05	39.36	10.19
	2003	7.55	5.40	6.55	0.00	5.88	1.23	5.00	10.00	−41.20	69.14	16.12	−35.70	47.82	29.48	13.86
	2004	4.20	5.70	0.04	0.00	7.06	4.07	6.25	10.00	−31.18	67.88	16.99	−27.02	46.94	31.06	16.99
	2005	8.09	7.49	6.99	0.00	7.06	6.17	2.00	0.00	−68.95	29.99	25.88	−59.75	20.74	47.31	2.77
	2006	9.70	7.80	8.38	0.00	7.06	6.17	2.00	0.00	−75.81	31.65	27.57	−65.69	21.89	50.40	2.20
	2007	9.70	7.80	8.38	0.00	7.06	6.17	2.00	0.00	−75.81	31.65	27.57	−65.69	21.89	50.40	2.20
	2008	9.70	8.08	8.38	0.00	7.06	6.17	2.00	0.00	−76.02	31.89	28.13	−65.88	22.05	51.43	2.54
	2009	9.70	8.26	8.38	0.00	7.06	6.17	2.00	0.00	−76.16	32.04	28.50	−65.99	22.16	52.10	2.75
	2010	9.70	8.24	8.38	0.00	7.06	6.17	2.00	0.00	−76.14	32.03	28.46	−65.98	22.15	52.03	2.73
	2011	9.70	8.06	8.38	0.00	7.06	6.17	2.00	0.00	−76.01	31.87	28.10	−65.87	22.04	51.38	2.52
	2012	9.70	8.03	8.38	0.00	7.06	6.17	2.00	0.00	−75.99	31.85	28.05	−65.85	22.03	51.27	2.48

Table 12 "Attijari" banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
Attijari	2002	3.02	3.34	3.46	0.00	4.71	3.09	3.25	10.00	−29.52	55.52	9.62	−25.58	38.39	17.58	10.13
	2003	2.85	6.81	4.04	0.00	7.06	6.17	4.25	10.00	−46.83	64.37	18.31	−40.58	44.52	33.47	12.47
	2004	3.75	5.07	1.05	7.70	7.06	8.27	2.00	10.00	−55.92	83.57	14.66	−48.46	57.79	26.79	12.04
	2005	4.93	4.94	1.69	7.21	6.47	6.67	2.25	10.00	−52.61	82.88	14.48	−45.59	57.32	26.48	12.74
	2006	2.73	4.54	0.02	6.22	7.06	8.27	4.25	10.00	−48.77	82.02	12.63	−42.26	56.72	23.08	12.51
	2007	8.24	7.80	9.88	0.00	6.47	10.00	4.25	0.00	−88.73	33.37	25.64	−76.89	23.08	46.87	-2.31
	2008	8.24	7.76	9.79	0.00	6.47	10.00	4.25	0.00	−88.50	33.28	25.60	−76.69	23.01	46.80	-2.29
	2009	8.24	8.06	10.00	0.00	6.47	10.00	4.25	0.00	−89.19	33.67	26.13	−77.28	23.28	47.77	-2.08
	2010	6.19	8.24	7.69	0.00	6.47	10.00	4.25	0.00	−79.73	31.72	25.35	−69.09	21.94	46.34	-0.27
	2011	6.35	8.16	7.74	0.00	6.47	10.00	4.25	0.00	−80.12	31.73	25.31	−69.43	21.95	46.28	-0.40
	2012	6.39	8.37	7.70	0.00	6.47	10.00	4.25	0.00	−80.28	31.90	25.80	−69.56	22.06	47.16	-0.11

Table 13 "ATB" banking risk result

Bank	Year	$E(C)$	$E(PI)$	$E(PE)$	$E(P)$	$E(T)$	$E(A)$	$E(AI)$	$E(D)$	Y_1	Y_2	Y_3	BR_1	BR_2	BR_3	BR
ATB	2002	7.90	8.11	6.83	0.00	6.47	2.22	9.00	0.00	−49.45	49.23	21.53	−42.85	34.05	39.36	10.19
	2003	7.55	5.40	6.55	0.00	5.88	1.23	5.00	10.00	−41.20	69.14	16.12	−35.70	47.82	29.48	13.86
	2004	4.20	5.70	0.17	0.00	7.06	4.07	6.25	10.00	−31.46	67.96	16.94	−27.27	47.00	30.97	16.90
	2005	8.09	6.11	6.99	0.00	6.47	4.44	2.25	0.00	−60.55	29.36	21.93	−52.47	20.30	40.09	2.64
	2006	9.70	7.80	8.38	0.00	7.65	6.67	2.00	0.00	−78.31	32.62	28.09	−67.86	22.56	51.35	2.02
	2007	9.70	7.80	8.38	0.00	7.65	7.90	5.75	0.00	−81.15	40.91	26.67	−70.32	28.29	48.76	2.24
	2008	9.70	7.80	8.38	0.00	7.65	6.67	2.00	0.00	−78.31	32.62	28.09	−67.86	22.56	51.35	2.02
	2009	9.70	7.80	8.38	0.00	7.65	7.90	5.75	0.00	−81.15	40.91	26.67	−70.32	28.29	48.76	2.24
	2010	9.70	7.80	8.38	0.00	7.65	7.90	5.75	0.00	−81.15	40.91	26.67	−70.32	28.29	48.76	2.24
	2011	9.70	7.80	8.38	0.00	7.65	6.67	2.00	0.00	−78.31	32.62	28.09	−67.86	22.56	51.35	2.02
	2012	9.70	7.80	8.38	0.00	7.65	7.90	5.75	0.00	−81.15	40.91	26.67	−70.32	28.29	48.76	2.24

described in this research, the Tunisian banking sector did not detect a big risk due to the nature of the banking sector in the country, which applies all prudential international norms to secure the sector.

7 Conclusions

The objective of our study was to investigate the relationship between internal governance mechanisms and banking risk in the Tunisian context. Particular emphasis is placed on the impact of ownership structure (ownership concentration, presence of institutional investors, presence of foreign shareholders, and participation of the state) and the board (size of board of directors, institutional directors, independent directors, and duality of leadership) on banking risk. The empirical results show that the internal mechanisms of governance present diverging effects on the financial risk of the Tunisian banks in our case study (i.e., credit risk). For this reason, we developed a global model and generic process to represent all relations between corporate governance and banking risk. This model can be applied to any bank to help managers and stakeholders make decisions in real time. This model is based on an architecture that can show all steps, beginning with user preferences and ending with a decision. This decision is the goal of any internal or external user and shows how the risk affects the bank.

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