

Information-Guided Governance of Public Companies in Morocco: Measuring Efficiency by the Integral Method Based on Choquet

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Abstract: We are interested in the problem of multi-criteria aggregation in governance of the Public Establishments and Enterprises (PEE). This raises the problem of considering the multidimensional aspect of the relevance of. To address this problem, we propose a new approach based on the Choquet integral. The results obtained are satisfactory and confirms those obtained by the method based on the Sugeno integral. This approach allows and classifies all the companies concerned and in the same time, facilitates the assessment of the efficiency of the governance of each company. It also has the advantage of making available to the state shareholder a decision-making means capable of modulating its means of intervention according to the maturity of the governance system of each public establishments or enterprises.

Key words: Gouvernance, efficiency, efficacy, multidimensional pertinence agregation, fuzzy measure, Choquet integral, relevance

INTRODUCTION

In several scientific literature, Black *et al.* (2003) and Drobetz *et al.* (2003), we consider governance to be efficient as it maximizes the value of the company through better resolution of conflicts of interest between the different parties. As a result, the effectiveness of an entity's governance is linked to the respect of standards in relation to the following three criteria:

- The proper functioning of the board of directors and its specialized committees
- Risk management
- Improving disclosure of information

Erramli and Khalfaoui (2016) have used an approach based on the Sugeno integral for multidimensional relevance aggregation in the field of governance. This approach has allowed the escape of the problem of independence of the criteria of governance posed in the conventional aggregation operators. Considering the importance of the results obtained by this approach, we propose in this research to measure governance via another method based on choquet integral.

The aim being is to introduce a new approach to measuring the efficiency of corporate governance by using the fact that the choquet integral can be used to

model all the interactions and dependencies that can exist between different dimensions of relevance. To validate the results obtained, we opted for the use of the same variables and sample adopted by Erramli and Khalfaoui (2016).

Brief state of the art in measuring governance efficiency: A review of the empirical studies, on this topic shows that each study differs from the others in incorporating a very specific element of governance.

Indeed, several researchers (Almazan and Suarez 2003; Alves and Mendes, 2004; Bai *et al.*, 2004; Black *et al.*, 2003a, b; Black, 2001; Campos *et al.*, 2002; Denis and McConnell, 2003; Doidge *et al.*, 2004; Gompers *et al.*, 2003; Koehn and Ueng, 2005; SP., 2002) proposed governance indices based on:

- The organization of the Board of Directors (BD), particularly the frequencies of its meetings
- The presence of independent directors (administrators)
- Functioning of specialized committees
- Transparency and disclosure of information

Other researchers (Black *et al.*, 2003; Drobetz *et al.*, 2003; BIS., 2016) have incorporated the audit committee and internal audit as a specific element in their study.

Mohanty (2003) adopts another approach in the calculation of the governance index. This approach is based on the following principle: "A firm with good governance is a firm that pays taxes to the state". Correia *et al.* (2009) developed a governance index specific to Brazilian companies. Their findings highlighted four main components:

- Transparency
- Protection of investors
- Compensation
- The composition of the board of directors and the ownership structure

Erramli and Khalfaoui (2016) have used an approach based on the measurement of fuzziness and the Sugeno integral to measure the efficiency of the governance of a sample of Establishments and Public Enterprises (EEP) in Morocco. In this context, they assessed the measurement of governance according to four variables related to the internal mechanisms of the management and operation of a company, namely:

- The organization and functioning of the board of directors
- Functioning of the specialized committees
- Disclosure of information
- The maturity of the risk management system

MATERIALS AND METHODS

The use of Choquet integral (Grabisch and Labreuche, 2010) has been used here because they are used as qualitative aggregation functions to evaluate objects that depend on several criteria. They also make it possible to simplify the calculation of aggregation.

To facilitate its understanding, we thought it advisable to recall the notions of fuzzy and integral measure of Choquet and to work on an example of application.

Concept of fuzzy measurement: For a non-empty finite set $X = (x_1, x_2, \dots, x_m)$ and the set of parts $P(X)$ of X , a fuzzy measure denoted μ and an application of $P(X)$ in $[0, 1]$ which satisfied the following properties:

$$\begin{aligned} \forall A, B \in X, \text{ si } A \subseteq B \text{ then } g(A) &\leq g(B) \\ g(\emptyset) &= 0 \text{ and } g(X) = 1 \\ \text{if } A \cap B = \emptyset \text{ then } g(A \cup B) &= g(A) + g(B) + \\ \lambda g(A)g(B) \text{ with } \lambda &\in [-1, +\infty[\end{aligned}$$

The parameter λ is obtained by solving the following equation:

$$1 + \lambda = \prod_{i=1}^{i=m} (1 + \lambda g^i)$$

With:

$$g^i = g(\{x_i\})$$

Once the value λ has been determined, the different fuzzy measurement values $g(X)$ that can be used in the aggregation process are evaluated by the following relation:

$$g(X) = \prod_{i=1}^{i=m} \left[\frac{(1 + g^i)}{\lambda} - 1 \right]$$

Choquet integral: The Choquet integral is defined as follows:

$$Ch_{\mu}(X) = \sum_{i=1}^{i=m} (f(x_{(i)}) - f(x_{(i-1)})) g(A_{(i)})$$

With $N = \{1, \dots, n\}$: The set of criteria; $f: N \rightarrow [0, 1]$: The evaluation function avec $f(x_{(i)}) \leq f(x_{(i+1)}) \leq \dots \leq f(x_{(n)})$; $g: 2^N \rightarrow L$: Is fuzzy measure; $X = (X_1, \dots, X_n) \in L^n$: An alternative; $()$: A permutation over N such that $x_{(1)} \leq \dots \leq x_{(n)}$; $A_{(1)}, \dots, A_{(n)}$: Are subsets of N such as for:

$$i = 1, \dots, n \quad A_{(i)} = \{(i), \dots, (n)\} \text{ et } A_{(n+1)} = \emptyset$$

The Choquet integral gives a score between the minimum and maximum of the partial evaluation.

Application example: $N = \{1, 2, 3\}$ a set of criteria. g is a fuzzy measure defines $2^N \rightarrow [0, 1]$ such that: the weights or measures of importance of each criterion are:

$$g^1 = 0.4, g^2 = 0.3 \text{ et } g^3 = 0.2$$

The evaluation function $f: N \rightarrow [0, 1]$ is defined as follows:

$$f(x_1) = 0.4, f(x_2) = 0.6 \text{ et } f(x_3) = 0.8$$

Step 1: Calculation of parameter λ :

$$1 + \lambda = \prod_{i=1}^3 (1 + \lambda g^i)$$

So:

$$\begin{aligned} 1 + \lambda &= (1 + \lambda g^1) \times (1 + \lambda g^2) \times (1 + \lambda g^3) = \\ &= (1 + 0.4\lambda) \times (1 + 0.3\lambda) \times (1 + 0.2\lambda) \end{aligned}$$

Table 1: Example of calculation of the fuzzy measurement

A	g (A)	A	g (A)
\emptyset	0.0	$\{x_1, x_2\}$	0.7446
$\{x_1\}$	0.4	$\{x_1, x_3\}$	0.5223
$\{x_2\}$	0.3	$\{x_2, x_3\}$	0.7323
$\{x_3\}$	0.2	$\{x_1, x_2, x_3\}$	1.0000

This implies:

$$0.024\lambda^3 + 0.26\lambda^2 - 0.1\lambda = 0$$

Solving this equation gives the following solutions:

$$\lambda_1 = -11.87; \lambda_2 = -0.3719 \text{ et } \lambda_3 = 0$$

Since, $\lambda \in [-1, +\infty]$ [and if $\lambda = 0$ the model will be additive (trivial case), we thus retain the value:

$$\lambda = -0.3719$$

Step 2: The fuzzy measurement for all subassemblies (Table 1).

Step 3: Calculating the choquet integral the choquet integral is then written, taking into account the fact that:

$$f(x_1) = 0.4 \leq f(x_2) = 0.6 \leq f(x_3) = 0.8$$

$$Ch_\mu(X) = \sum_{i=1}^3 (f(x_i) - f(x_{i-1}))g(A_i)$$

$$\begin{aligned} Ch_\mu &= f(x_1)g(\{x_1, x_2, x_3\}) + (f(x_2) - f(x_1))g(\{x_1, x_2\}) \\ &+ (f(x_3) - f(x_2))g(\{x_3\}) = \\ &0.4 + 0.2 \times 0.5223 + 0.2 \times 0.2 = 0.54446 \end{aligned}$$

Specimen and data source: In order to compare the results obtained in choquet integral, instead of the Sugeno integral for the measurement of the efficiency of the governance of public enterprises in Morocco, we are using the same variables and same sample. This sample includes public establishments operating in the market sector and public limited companies with majority direct public participation.

The data used refer to the year 2014 and come from different sources including reports published by the Ministry of Economy and Finance (BAM., 2014). Activity reports on the companies websites forming the sample (SP., 2002) as well as the reports of the Court of Auditors in Morocco (BIS, 2016).

Table 2: Measurement parameters for criterion 1

Measurement parameters	Appreciation	Rating
Size of board of directors	If the number of directors is <12	3
	If the number of directors is <18	2
	If the number of directors is <24	1
Existence of Independent Administrators (ID)	2 or more Ids	2
	1 ID	1
	0 ID	0
Frequency of meetings	If the meeting frequency of the BD is greater than or equal to 4	5
	If the meeting frequency of the DB equal to 3	4
	If the meeting frequency of the DB equal to 2	3
	If the meeting frequency of the DB equal to 1	1

Criterion 1: Organization and functioning of the BD; Objective: To assess the functioning of the CA including its size, the presence; within the independent directors and the frequency of its meetings

Table 3: Measurement parameters for criterion 2

Measurement parameters	Appreciation	Notation
Functioning of the audit committee	If the committee's annual meeting frequency is 4 or more	5
	If the committee's annual meeting frequency is 3	4
	If the committee's annual meeting frequency is 2	3
	If the committee's annual meeting frequency is 1	2
	If the committee exists but is not operational	1
	If the committee does not exist	0
Operationalization of the Strategic and Investment Committee (SIC)	The SIC is operational	2
	The SIC exists but is not operational	1
	The SIC does not exist	0
Existence of other specialized committees (other than the audit committee and the SIC)	The number of specialized committees is ≤ 3	3
	The number of specialized committees is 2	2
	The number of specialized committees is 1	1
	Inexistence of specialized committees	0

Criterion 2: Functioning of the specialized committees; Objective assess the operation of the specialized committees through the operation of the audit committee, the operationalization of the strategic committee and investment and the existence of other specialized committees (compensation, governance)

Variables used: The measure of governance is assessed according to four criteria:

- Organizing the functioning of the board
- The functioning of the specialized committees
- Disclosure of information
- The maturity of the risk management system

The objectives and the assessment methods used for the measurement parameters for each criterion are as follows in Table 2-5.

Table 4: Measurement parameters for criterion 3

Measurement parameters	Appreciation	Notation
Quality of disclosure of information	No communication	0
	One communication per year, not audited	1
	A single communication, per year, audited	2
	One communication per year, certified	3
	Two communications per year, one of which is audited	4
	Two communications per year, one of which is certified	5
	Two communications per year, one certified and the other audited	6
	Four communications per year, one certified and one audited	7
	Four papers per year, one certified and two audited	8
	Four papers per year, one certified and three audited	9
	Four audited communications per year, including at least one certified	10

Criterion 3 : Disclosure of information; Objective : enjoy the dimension of transparency of the company through its financial communications in the frequency and quality of their disclosure

Table 5: Criterion measurement parameters 4

Parameters	Appreciation	Notation
Level of maturity of the risk control system	Awareness of the importance of risk control but not materialized	1
	Some risks identified but the non-existent risk device	2
	Existing but not materialized risk device	3
	Materialized but non-operational risk device	4
	Operational risk device	5
	Existence of a risk mapping but not used by the risk device	6
	Risk system driven by risk mapping	7
	Good steering of the risk device but no control	8
	Existence of a Global Risk Management	9
	Overall management of operational risk taking into account feedback	10

Criterion 4: Maturity of the risk management system; Objective: Enjoy the risk mastery of processes within the company in three parts: existence of a comprehensive risk management, existence of an entity responsible for monitoring risks, existence of a risk map

RESULTS AND DISCUSSION

Empirical study and results

Calculation of governance scores using Choquet's method

Basic data: We consider the problem of aggregation of multidimensional relevance as a problem of multicriteria decision-making. More precisely in the context of governance we are confronted to find a consensus on the classification of a set E_i of companies from a total set according $E = \{E_1, E_2, E_3, \dots, E_{35}\}$ to a set of criteria x_i . Each criterion x_i belongs to the set $N = \{x_1, x_2, x_3, x_4\}$ of dimensions of relevance with:

- x_1 : Criterion 1 (Organization and functioning of the board)
- x_2 : Criterion 2 (Functioning of specialized committees)
- x_3 : Criterion 3 (Disclosure of information)
- x_4 : Criterion 4 (Maturity of the risk management system)

$F(x_i)$ is the evaluation function for the criterion x_i . The weights or measures of importance of each criterion are:

$$g^1 w_1, g^2 = w_2, g^3 = w_3, g^4 = w_4$$

The evaluation functions) ($f(x_i)$ for each company E_i , calculated using the grids presented above are as follows Table 6. In our study, we retain the following weights:

Table 6: Valuation of companies by criterion

Company	$f(x_1)$	$f(x_2)$	$f(x_3)$	$f(x_4)$
E_1	0.7	0.7	0.5	0.3
E_2	0.4	0.3	0.1	0.1
E_3	0.3	0.4	0.1	0.1
E_4	0.5	0.2	0.1	0.6
E_5	0.5	0.2	0.1	0.1
E_6	0.8	0.7	0.6	0.9
E_7	0.4	0.8	0.8	0.8
E_8	0.8	0.7	0.8	0.7
E_9	0.5	0.2	0.1	0.6
E_{10}	0.5	0.1	0.1	0.1
E_{11}	0.4	0.5	0.8	0.9
E_{12}	0.5	0.5	0.1	0.3
E_{13}	0.6	0.4	0.1	0.3
E_{14}	0.7	0.9	0.8	0.8
E_{15}	0.3	0.1	0.1	0.1
E_{16}	0.2	0.3	0.1	0.1
E_{17}	0.4	0.4	0.1	0.1
E_{18}	0.6	0.6	0.3	0.3
E_{19}	0.7	0.8	0.3	0.2
E_{20}	0.4	0.5	0.1	0.3
E_{21}	0.5	0.5	0.1	0.1
E_{22}	0.2	0.4	0.1	0.1
E_{23}	0.3	0.1	0.1	0.1
E_{24}	0.2	0.3	0.1	0.1
E_{25}	0.9	0.8	0.5	0.6
E_{26}	0.5	0.2	0.1	0.2
E_{27}	0.5	0.3	0.1	0.2
E_{28}	0.5	0.1	0.1	0.1
E_{29}	0.5	0.6	0.1	0.2
E_{30}	0.5	0.2	0.1	0.1
E_{31}	0.6	0.6	0.1	0.1
E_{32}	0.6	0.7	0.1	0.1
E_{33}	0.8	0.7	0.1	0.4
E_{34}	0.5	0.2	0.1	0.1
E_{35}	0.5	0.4	0.1	0.1

Table 7: Calculation of the fuzzy measurement for the subassemblies

A	$g \lambda (A)$	A	$g \lambda (A)$	A	$g \lambda (A)$
$\{x_1\}$	0.7	$\{x_1, x_3\}$	0.8547212	$\{x_1, x_2, x_3\}$	0.9488061
$\{x_2\}$	0.6	$\{x_1, x_4\}$	0.9475539	$\{x_1, x_2, x_4\}$	0.9866905
$\{x_3\}$	0.5	$\{x_2, x_3\}$	0.8040467	$\{x_1, x_3, x_4\}$	0.9801677
$\{x_4\}$	0.8	$\{x_2, x_4\}$	0.9264747	$\{x_2, x_3, x_4\}$	0.9694860
$\{x_1, x_2\}$	0.8856654	$\{x_4, x_4\}$	0.9053956	$\{x_1, x_2, x_3, x_4\}$	1

$$w_1 = 0.7, w_2 = 0.6, w_3 = 0.5, w_4 = 0.8$$

These weights were selected by Erramlim and Khalfaoui (2016), following a survey of a sample of the administrators of the 35 companies constituting the sample of the study.

Construction of the integral of Choquet: Considering the fact that :

$$\begin{cases} w_1 = g(\{x_1\}) = 0.7 \\ w_2 = g(\{x_2\}) = 0.6 \\ w_3 = g(\{x_3\}) = 0.5 \\ w_4 = g(\{x_4\}) = 0.8 \end{cases}$$

We find the parameter λ by solving the following polynomial equation:

$$1 + \lambda = \prod_{i=1}^{i=4} (1 + \lambda g^i)$$

So, we obtain:

$$0.168\lambda^4 + 1.066\lambda^3 + 2.51\lambda^2 + 1.6\lambda = 0$$

The solutions of this equation are:

$$\begin{cases} \lambda_1 = -2.6793636 + i1.5732273 \\ \lambda_2 = -2.6793636 - i1.5732273 \\ \lambda_3 = 0 \\ \lambda_4 = -0.9865100964 \end{cases}$$

Since, $\lambda \in [-1, +\infty[$ and if $\lambda = 0$ the model will be additive, we then retain the following value (Table 7):

$$\lambda = -0.9865100964$$

Thus, equation:

$$g(A \cup B) = g(A) + g(B) + \lambda g(A) \times g(B)$$

Table 8 . The construction of the Choquet integral for each firm is calculated according to the following equation:

$$Ch_\mu(X) = \sum_{i=1}^n (f(x_i) - f(x_{i-1}))g(A_i)$$

$$\text{avec } f(x(i)) \leq f(x(i+1)) \leq \dots \leq f(x(n))$$

Results analysis: Figure 1 shows the governance scores of each firm using the Choquet method. Governance efficiency scores for each company, calculated according to the Choquet integral, range from 0.24-0.8734. The arithmetic mean is 0.51 while the median is 0.45.

The evaluation of the efficiency of the governance of the same sample according to the integral of Sugeno has allowed to Erramli and Khalfaoui (2016) to identify six groups. Each group is composed of companies with the same score. The comparison of the scores of these groups with the results found is as follows Table 9:

- S_μ : Score obtained by Erramlim and Khalfaoui (2016) using the method based on the integral of Sugeno
- Ch_μ : Score obtained using the method based on the Choquet integral

Analysis of this table shows that: About 54% of the companies have scores below the sample mean according to the results of the two methods (groups 1-3). The governance of these companies which operate mainly in the sectors of Agriculture and Marine Fishing, Services and Development and Housing, suffers from the non-professionalization of their Board of Directors and the lack of good governance practices.

Group 4: Consisting of companies with a score ranging from 0.524-0.603, accounts for nearly 20% of the population studied. The governance structure of each company forming this group requires in particular, the operationalization of the specialized committees, the improvement of transparency and financial communication and the control of the risk management system.

Group 5: Composed of 3 companies, 2 of which have a score according to Choquet's method, higher than that

Table 8: Calculation of governance scores by Choquet method

Company	Ch _μ	Company	Ch _μ	Company	Ch _μ	Company	Ch _μ	Company	Ch _μ
E ₁	0.6669	E ₈	0.7855	E ₁₅	0.2400	E ₂₂	0.3086	E ₂₉	0.5244
E ₂	0.3471	E ₉	0.5629	E ₁₆	0.2486	E ₂₃	0.2400	E ₃₀	0.3986
E ₃	0.3498	E ₁₀	0.3800	E ₁₇	0.3657	E ₂₄	0.2486	E ₃₁	0.5428
E ₄	0.5629	E ₁₁	0.8486	E ₁₈	0.5657	E ₂₅	0.8458	E ₃₂	0.6028
E ₅	0.3986	E ₁₂	0.4745	E ₁₉	0.7091	E ₂₆	0.4087	E ₃₃	0.7317
E ₆	0.8734	E ₁₃	0.5259	E ₂₀	0.4459	E ₂₇	0.4272	E ₃₄	0.3986
E ₇	0.7878	E ₁₄	0.8569	E ₂₁	0.4543	E ₂₈	0.3800	E ₃₅	0.4357

Table 9: Score obtained by using integral sugeno and chouquet integral

Group1 (Sμ = 0.3)		Group 2 (Sμ = 0.4)		Group 3 (Sμ = 0.5)		Group 4 (Sμ = 0.6)		Group 5 (Sμ = 0.7)		Group 6 (Sμ = 0.8)	
E _i	Chμ	E _i	Chμ	E _i	Chμ	E _i	Chμ	E _i	Chμ	E _i	Chμ
E ₁₅	0.24000	E ₂₂	0.30857	E ₁₀	0.38000	E ₂₉	0.52437	E ₁	0.66689	E ₈	0.78547
E ₂₃	0.24000	E ₂	0.34713	E ₂₈	0.38000	E ₁₃	0.52590	E ₁₉	0.70915	E ₇	0.78779
E ₂₄	0.24857	E ₃	0.34976	E ₅	0.39857	E ₃₁	0.54283	E ₃₃	0.73171	E ₂₅	0.84580
E ₁₆	0.24857	E ₁₇	0.36570	E ₂₀	0.39857	E ₄	0.56294			E ₁₁	0.84857
				E ₂₄	0.39857	E ₉	0.56294			E ₁₄	0.85695
				E ₂₆	0.40867	E ₁₈	0.56570			E ₆	0.87342
				E ₂₇	0.42724	E ₃₂	0.60283				
				E ₂₅	0.43570						
				E ₂₀	0.44590						
				E ₂₀	0.45427						

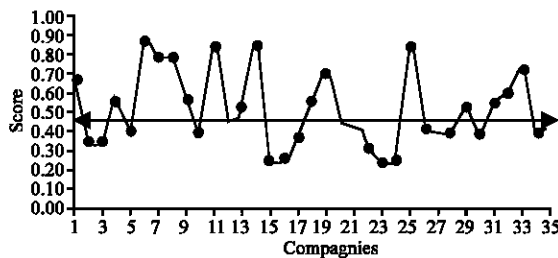


Fig. 1: Choquet's governance scores depending to choquet method

calculated according to the Sugeno method (0.709 and 0.739 against 0.7). These companies, operating in the infrastructure and transport sector had these scores thanks to the dynamic operation of their boards of Directors and their specialized committees. However, efforts remain to be made in particular in the area of disclosure and risk control.

Group 6: Accounts for nearly 17% of the study population, contains companies with the highest governance scores. This group is distinguished, compared to other groups, by the good performance of its companies in terms of risk management and practices transparency and dissemination of information. It contains 4 companies operating in the financial sector, the Office Cherifien of Phosphates (OCP) and The Royal Airline Company (RAM).

The company with the highest score according to Choquet's method is Bank Al-Maghrib. This result is due, inter alia to the fact that companies operating in the financial sector are subject to the guidelines required by

the Basel Committee standards (10) which involve setting up a governance system appropriate to the profile of Risk of these entities and their systemic importance.

The second score, according to the same method is registered by OCP which is a world leader in the phosphates sector and the largest company in Morocco. Recovering The Royal Airline Company (RAM) among the companies in this group confirms the efforts made under the program contract between the Moroccan government and the company in particular with regard to the implementation of an efficient governance system. This company is also characterized by the presence of two independent directors on its board of directors.

By Choquet's method, we were able to have a ranking within each group. This classification has the advantage of making it possible to assess the efficiency of the governance of each company independently of the group.

CONCLUSION

To measure the efficiency of the governance of public enterprises in Morocco, we have opted for four variables related to the internal mechanisms of the management and operation of any institution. These include the organization and functioning of the board of directors, the operation of specialized committees, the ability to disclose information and the maturity of the risk management system.

We thus find ourselves faced with a problem of considering the multidimensional aspect of relevance with, the need to identify a method of efficiently combining the various dimensions in order to arrive at the

global relevance scores. Erramli and Khalfaoui (2016) have used a new approach based on fuzzy measurement and the integral of Sugeno to study this problem.

In this study, we proposed another approach based on the Choquet integral. We have adopted the same sample of 35 Moroccan public companies.

RECOMMENDATIONS

The results obtained show the relevance of our proposal. Indeed, we were able to confirm the results found using the integral of Sugeno. Moreover, our approach makes it possible to rank all the companies forming the sample. This classification has the advantage of facilitating the assessment of the efficiency of the governance of each company independently. It also has the advantage of allowing the State shareholder to modulate its means of intervention according to the maturity of the governance system of each public company.

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