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ORIGINAL PAPER

PREDICTING EMPLOYEES EVALUATION PERFORMANCE USING SIMULATION AND MATHEMATICAL MODELING

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Abstract. *Any organization makes assessments to achieve improvements in employee activity or in those processes that do not bring the desired performance. If, through various methods used to determine the degree of fulfillment of performance by employees, these performances are met, then the employees should be rewarded financial or nonfinancial, and if they are not fulfilled, employees must be sent to various training programs, learning or development processes in order to improve their performance.*

In this article we analyze some methods and models to assess performance and we are also present the advantages and disadvantages of their use in organizations. We have also realized a case study in an organization that uses as evaluation method, the Gauss method, showing its importance by using simulation process, and showing its benefits and disadvantages of using such a method of performance evaluation.

Keywords: *performance, methods of performance evaluation, matematical modeling, Gauss method, efficiency.*

1. PERFORMANCE EVALUATION- IMPORTANCE FOR EMPLOYEES AND ORGANIZATION

Performance is what it really matters for an organization to be effective [1]. Performance which is measured is easy to manage [2]. Performance must be evaluated depending on the established objectives, the job, and the situation [3].

To see the importance of performnce evaluation, we give some definitions: it is a process of analysing the strengthes and the waknesses of an employee [1]; it is the base of evaluation audit for every employee [4]; consists in the estimation of the degree in which the employees fulfill their tasks [5]; it is an avtivity of comparing the employees results, behaviours, and potential with the tasks, objectives, and the job demands [6]; it is an important and powerful process, necessary to correct planning for any organization [3]; it is an important way of systematic work communication between employers and employees [7].

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2. SCOPE AND OBJECTIVES OF PERFORMANCE EVALUATION

The scope of performance evaluation [2]: administrative actions: dismissals, wage cuts, resignations, transfers, promotions, development actions: progress of career development opportunities, coaching, mentoring, identifying the strengths and weaknesses of employee performance.

General objectives of performance evaluation [7]: to identify the current level of an individual's work performance; to identify the strengths and weaknesses of an employee; to help the employees to improve their performance; to provide the basis to reward employees according to their contribution to achieving organizational goals; to motivate individuals; to identify training needs and professional development; to identify potential performance; to provide information for planning succession.

3. METHODS AND MODELS USED IN ORGANIZATIONS FOR PERFORMANCE EVALUATION

To evaluate employees performance the organizations use different methods and models such as:

Free evaluation

Generally, it is starting from a text writen by the evaluator considering the strengthes and the weaknesses of the evaluated employee in order to determine the chance of getting success and the necessary measure for correction [8].

The evaluation matrix

It is based on a list of criteria, and to each criterion it is attached an appreciation scale [5].

Evaluation scales (grapfical or multiple)

First method is easy to use and conceive, and requires less time for its development; allows analysis and comparing of different employees; the ssecond method is consisting in develpping a list of attributes, each being detailed through some degrees [9].

Scales with behavioral observations

It is representing a type of sclae which uses some sets of speficific behaviours necessary for a job and grouped among different work dimensions. It is using Likert sclae in analysing different aspects of work performance.

360 degrees evaluation

It is often used and is based on subjectives concurrent evaluations, received from head of departments, colleagues, and customers ; it is also called the “multievaluator” method [10].

Evaluation interview

It is a formal meeting between employer and the employee and are discussed the information from the evaluation form and then are taken some key-decisions regarding the payment, the promotion or the training [7].

Assessment centres

This method is formed by a series of exercices such as: group disscutions or speeches, where a group of candidates is reunited for one or three days, in a pleasant and quite place in order to solve some issues. Are obtained many information about the candidates, the candidates have the necessary time for integration and these meetings are useful and interesting to find the right candidate for the job

Comparative methods for evaluation

The evaluator ranks all the employees, from the best to the weakest, on a scale with many steps, so the first to have the highest score and the lowest last [9]: simple comparison **-** It is consisting in writing the names of evaluated employees on a note and then it is made a ranking by the evaluator depending on a criteria; pairs comparing **-** It is a systematic comparison made for an employee with the others from the group; forced distribution comparing (Gauss) - It was used by orgaizations as an aggresive method in order to create a connection between performance and the compensation system [11].

4. NORMAL DISTRIBUTION – DEFINITIONS, PROPERTIES, AND IMPORTANCE IN EMPLOYEES EVALUATION

Definition: A continuous randomly variable has a normal repartition, or normal distribution (Gaussian), $X \in N(\mu, \sigma^2)$, if its probability intensity is like:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) \qquad x \in R$$

where μ is the average value of variable X (exceptation value) and σ^2 is the variance of the variable.

If $\mu = 0$ and $\sigma^2 = 1$ then X is called standardly normal. In this case is noted as $X \in N(0,1)$.

Properties:

1. The density of probability is positive, $f(x) \geq 0, \forall x \in R$.
2. $\int_{-\infty}^{+\infty} f(x)\,dx = 1$
3. The graph of f is symetrical with the vertical line $x = \mu$, has a maximum point $V\left(\mu, \frac{1}{\sigma\sqrt{2\pi}}\right)$ and two inflexion points $A\left(\mu - \sigma, \frac{1}{\sigma\sqrt{2\pi e}}\right)$, $B\left(\mu + \sigma, \frac{1}{\sigma\sqrt{2\pi e}}\right)$. The form of graph is the one of a bell, known as the Gauss bell.
4. $\lim_{x\to\infty} f(x) = \lim_{x\to-\infty} f(x) = 0$.

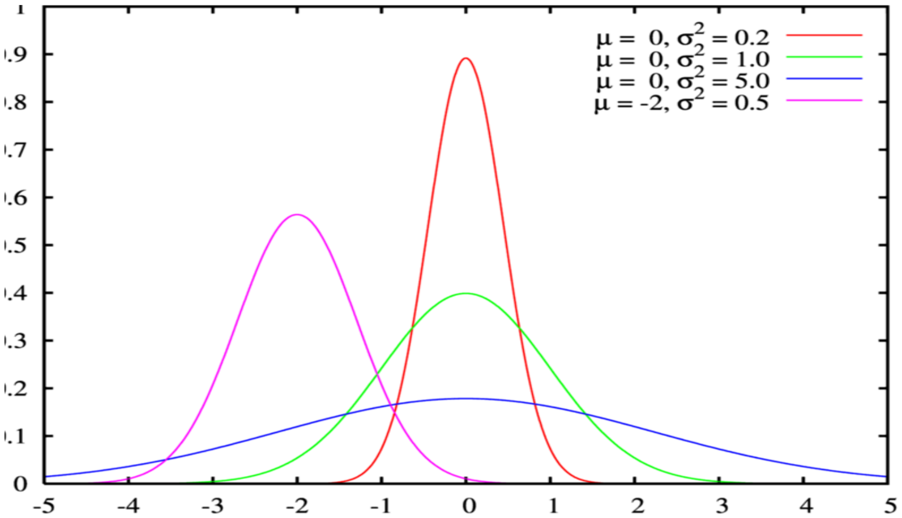

Figure 1. The Gauss bell.

Proposition: If $X \in N(\mu, \sigma^2)$ then the distribution functions of X has the following form:

$$F_X(x) = P(X < x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} exp\left(-\frac{(t-\mu)^2}{2\sigma^2}\right) dt$$

and reprezents hte probability for the variable to take values smaller then x, $\forall x \in R$.

Properties:

1. With the help of repartition function there are calculated the following probabilities:
Be $a, b \in R$ then:

$$P(a < X < b) = P(a \le X < b) = P(a < X \le b) = P(a \le X \le b) = F(b) - F(a).$$

$$P(X > a) = P(X \ge a) = 1 - F(a).$$

2. $F(\infty) = 1$, $F(-\infty) = 0$, F is continuous, derivable and increasing.
3. If $X \in N(0,1)$, is a normal randomly standard variable then the repartition function has the following form:

$$F_X(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} exp\left(-\frac{t^2}{2}\right) dt = \Phi(x).$$

Even if the function under the integral is continuous and admites primitives, this it cannot be expressed through elementary functions. $\Phi(x)$ is the integral function of Lagrange whose variables are tabulated.

4. The area of sub-graph for the density of probability function $f(x)$ is equal with $F_X(\infty) = 1$. Parts of the sub-grapf area are representing different events probabilities.

*Proposition:*If X is a normal random variable with the average μ and the și the dispersion σ^2 then $\frac{X-\mu}{\sigma}$ is a normal standard variable, with the average equal to zero and dispersion equal with one:

$$P(a < X \le b) = P\left(\frac{a-\mu}{\sigma} < \frac{X-\mu}{\sigma} < \frac{b-\mu}{\sigma}\right) = \Phi\left(\frac{b-\mu}{\sigma}\right) - \Phi\left(\frac{a-\mu}{\sigma}\right).$$

If $a = \mu - n\sigma$ and $b = \mu + n\sigma$ it will be obtained

$$P(\mu - n\sigma < X < \mu + n\sigma) = P\left(-n < \frac{X-\mu}{\sigma} < n\right) = \Phi(n) - \Phi(-n)$$

where n is a natural number.

For $n = 1$, $P(\mu - \sigma < X < \mu + \sigma) = P\left(-1 < \frac{X-\mu}{\sigma} < 1\right) = \Phi(1) - \Phi(-1) = 0{,}6826$.

For $n = 2$, $P(\mu - 2\sigma < X < \mu + 2\sigma) = P\left(-2 < \frac{X-\mu}{\sigma} < 2\right) = \Phi(2) - \Phi(-2) = 0{,}9545$.

And for $n = 3$, $P(\mu - 3\sigma < X < \mu + 3\sigma) = P\left(-3 < \frac{X-\mu}{\sigma} < 3\right) = \Phi(3) - \Phi(-3) = 0{,}973$.

This method, to be understood, its is presented in some definitions given by different specialists:

- Is a procedure involving the application of rules for system performance analysis and involving the distribution of performance in certain categories in order to ensure differentiation employees, depending on performance objectives [12]. It is an assessment of the type employed / standard.
- Implies the existence of supervisors to establish the percentage of employees in various performance categories [1].
- Is seen by US companies as a tool for assessing individual performance and skills creation, growth performance among employees [11].
- Allows placement or distribution of employee performance on a scale (top performance, and very low average), making a priori assessment. It creates a challenge in providing feedback to employees, can make errors distribution drastically reduce evaluation managers authority and freedom, because distribution is forced and can lead to demotivation of employees [13].
- General Electric used this method of assessment, and for employees in low-performing category, it remains to agree that employees in the firm, unless they improve their performance [14].
- Grant value on a predetermined scale distribution, and within it there is a tendency to evaluate the performance of poor to very good on a 5-point scale; providing a very small percentage of employees with low performance [3].

Such a forced distribution supposes realising a normal curve which may be devided in five proportional categories [1, 3]:

- 2% of employees have very good performance,
- 14% of employees have good performance,
- 68% of employees have average performance,
- 14% of employees have weak performance,
- 2% of employees have the weakest performance.

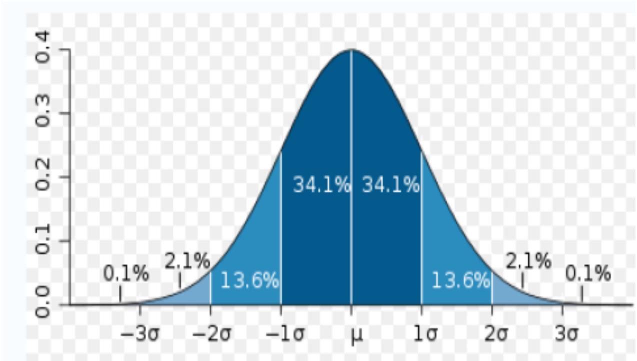

Figure 2. Forced distribution of employees after the performance level [2].

Advantages of using this method:

- Discipline and rigour into the performance management process.
- Rewards high performing staff.
- Provides cost containment for salaries and bonuses and has been used with success in companies with high performance culture.
- Reduces the burden on high performers who often have to "carry" the workload from poor performing staff and may push an organization towards a high performance culture by raising the talent bar higher.
- Instead of negatively affecting morale, it actually can increase it by having staff work with more talented people.
- Encourages open dialogue among managers on how their staff are really doing relative to everyone else.
- Creates morale and employee relations problems.
- Attracts unwanted legal action through discrimination claims in the USA.
- May cause an organization to inaccurately rate employees based on their performance when compared to their actual performance objectives which can leave staff feeling bitter and cheated.
- Does not consider or account for the impact of training and development that can push a performance curve to the right.
- Has the potential for undermining teamwork and cooperation as employees try and protect their ranking relative to their peers.
- Companies implementing Forced Distribution must also contend with the cultural shock and acceptance problems that such a program will invoke.
- Implementing a Forced Distribution can have an impact on employee loyalty and can impact turnover.

Dizadvantages - There are many critics braught to this method:

- It is not fair and clear, it is not flexible in allocating the resources between groups [12].
- It is difficult considering the explications the evaluators must give to each employee, why he/she is introduced in some group.
- It is producing anxiety for analysed employees (the evaluators are getting through many trails) [2]
- It is sometimes incorect, cinical and even distructive [4].
- Be detrimental to morale. We want high-performing workplaces, yet we also want people to enjoy coming to work. Can we have both?

- Emphasize individual performance at the expense of team performance. Employees will be less willing to "pitch in" and help others. Completing individual assignments becomes more important.
- Promote competition. If employees are ranked, will there be less cooperation?
- Creates and sustains a high-performance culture. Involuntary turnover is managed by eliminating weak performers and retaining strong performers.
- Correlates with total return to shareholders.
- Establishes well-defined consequences. Top-performing employees receive substantially larger rewards (i.e., base pay, bonus, options) than the average performers. Those falling at the lower end of the scale typically receive coaching and are on notice to improve performance.
- Makes performance management a corporate priority. With real consequences, performance management takes on renewed meaning.
- Lets employees know where they stand. One of the common complaints from employees is about the lack of feedback on their performance. Forced ranking sends a clear message as to how people stand, or fall.

5. CASE STUDY

Research Methodology

Sample size: The reasearch was made using data and information regarding the evaluation performance of 32 employees from a service institution.

Tools for data collection: observation and data analysis.

Tools for analysis: modeling and simulation process using statistical methods, Monte Carlo method, Excel program- Descriptive statistics, Hystogram.

Objective

The main objective of this paper is to measure the employees performance in organizations using the statistical, mathematical and IT in predicting the future employees performance in order to obtain performance.

Other objectives: calculating the sample variance for the series of numerical data and determining the future performance of employees (using Monte Carlo method); determination of the series homogeneity and determining the series asymmetry distribution; calculation of indicators and analysis of Kurtosis for central tendency curve.

Tool for collection of data- internal data and observation.

Sample size

The analysis was made on 32 employees from a department of an organization whose employees received from their direct managers the following scores on a 5 points evaluation scale: 6 employees received 5 points (19%), 12 employees received 4 points (37%), 8 employees received 3 points (25%), and the other 6 employees received 2 points (19%).

As objective we propose to predict the performance for the next year of evaluated employees and to see if is a normal distribution, using simulation and mathematical-statistical methods.

Step 1 Calculation of selection dispersion

It may be done using two ways:

1.1. Using statistical calculations:

$$s_x^2 = \frac{(x_1-\bar{x})^2+\ldots+(x_n-\bar{x})^2}{n-1} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1},$$

According to the presented formula, we will determine $\bar{x}$, $(x_i-\bar{x})^2$. The analyzed employees are grouped according to the received evaluation scores.

Table 1 Evaluation scores of employees

x_i	$(x_i-\bar{x})$	$(x-\bar{x})^2$	x_i	$(x_i-\bar{x})$	$(x-\bar{x})^2$
5	1,4375	2,066406	4	0,4375	0,191406
5	1,4375	2,066406	4	0,4375	0,191406
5	1,4375	2,066406	3	-0,5625	0,316406
5	1,4375	2,066406	3	-0,5625	0,316406
5	1,4375	2,066406	3	-0,5625	0,316406
5	1,4375	2,066406	3	-0,5625	0,316406
4	0,4375	0,191406	3	-0,5625	0,316406
4	0,4375	0,191406	3	-0,5625	0,316406
4	0,4375	0,191406	3	-0,5625	0,316406
4	0,4375	0,191406	3	-0,5625	0,316406
4	0,4375	0,191406	2	-1,5625	2,441406
4	0,4375	0,191406	2	-1,5625	2,441406
4	0,4375	0,191406	2	-1,5625	2,441406
4	0,4375	0,191406	2	-1,5625	2,441406
4	0,4375	0,191406	2	-1,5625	2,441406
4	0,4375	0,191406	2	-1,5625	2,441406
			$\bar{x}$=3,5625	0	31,875

$$S_{\bar{x}}^2 = \frac{31{,}875}{n-1} = \frac{31{,}875}{32-1} 1{,}028$$

Thus, the standard deviation is:

$$S_x=1{,}01$$

The variation coefficient is:

$$C_v = \frac{Sx}{\bar{x}} \times 100 = \frac{1{,}01}{3{,}5625} \times 100 = 28{,}35$$

The value obtained for Sx being smaller then 35% indicates that the data series is homogenous, and the average is reprezentative for the sample analyzed.

1.2. Using Monte Carlo method

Monte Carlo method is consisting in following the next steps:

1.2.1. Calculation of probabilities and the cumulated probabilities.

Table 2. Calculation of probabilities and the cumulated probabilities.

Scale	Nb. Of cases	Realization probability	Cumulated probability	Intervals
5-very good	6	0,19	0,19	0-0,19
4-good	12	0,37	0,56	0,19-0,56
3-average	8	0,25	0,81	0,56-0,81
2-weak	6	0,19	1,00	0,81-1,00
1-very weak	0	0,00	0	-
	N=32	1,00		

1.2.2. The cumulated probability is reprezented graphical

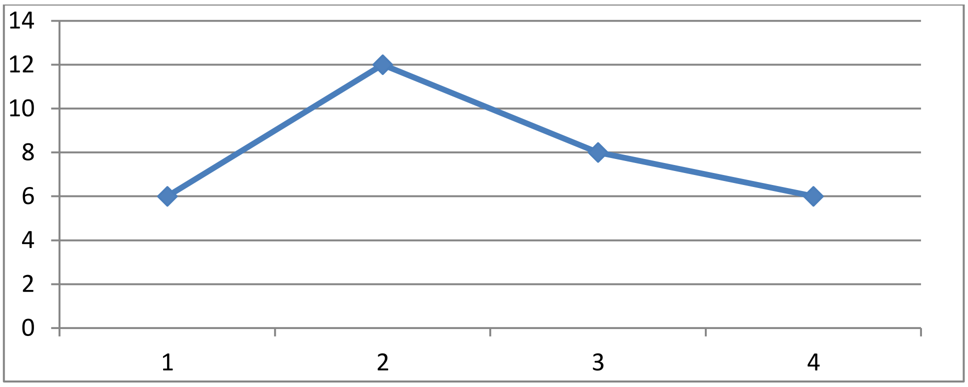

Figure 3. Grapfical representation of cumulated probability in the four situations.

1.2.3. Extracting 10 random numbers, between 0 and 1, calculating $\bar{x}$, standard deviation, the variation coefficient and the confidence interval.

Table 3. Calculating the average standard deviation, the variation coefficient and the confidence interval.

Nb.	Random nb.	Score	(xi-$\bar{x}$)	(xi-$\bar{x}$)^2
1	0,0317	5	1,44	2,07
2	0,965	2	-1,56	2,43
3	0,6174	3	-0,56	0,31
4	0,1511	5	1,44	2,07
5	0,02	5	1,44	2,07
6	0,5447	4	0,44	0,19
7	0,6969	3	-0,56	0,31
8	0,5773	3	-0,56	0,31
9	0,0306	5	1,44	2,07
10	0,2333	4	0,44	0,19
Total		39		12,02

$$\bar{x} = \frac{39}{10} = 3{,}9$$

$$S_x^2 = \frac{12{,}02}{10} = 1{,}202$$

$$Sx = \sqrt{1{,}202} = 1{,}096$$

$$C_v = \frac{1{,}096}{3{,}5625} \times 100 = 30{,}76$$

Cv being smaller then 35%, then the analysed series is homogenous.
N=10 (nb. Of experiments), g=N-1=9 (degree of freedom)
σ=0,05 (permited error), (1-σ)=0,95 (confidence interval)
$t_{\sigma/2,g} = t_{0,05/2;N-1} = t_{0,025;9}$ =2,2622 (according to t distribution)
The interval which indicates that the obtained scores for the future year is given by the formula:

$$(\ddot{x} \mp t_{\frac{\sigma}{2};N-1} * \frac{\sigma}{\sqrt{N}} = (374{,}5 \mp 2{,}09 * \frac{115{,}86}{4{,}47}) = (374{,}5 \mp 54{,}17)$$

$$= 3{,}5625 \pm 2{,}2622 \times \frac{1{,}096}{3{,}16} = 3{,}5625 \pm 0{,}78$$

= (2,78-4,34)

Thus, the predicted evaluations for the future may take values between the interval 2,78 and 4,34. The found interval is large enough even if the number of experiments is not too big (N=10).

Step 2. Determining the asymetry using Gaussian distribution

One of the method aplicated to determine if the series of frequencies is asymetric is by comparing the central tendency indicators.

Skewness = - 0,18 shows the type of asymmetry (pozitive or negative), and in our case the value is ngative, which shows the series presents a negative pronounced asimmetry, because is close to 0.

In this series prevail the big scores; the mode is situated in the right of the stream and as median (Me=4) is bigger then the average (m=3,6525), rezults that the analysed data series prezents negative asymmetry.

Conclusion: Comparing the obtained distribution and the normal distribution according to the studies.

Table 4 Systematization of the series into a series of cumulated frequencies

Nb.	Variation intervals k	Scores (%)	Absolute frequency
1	Very good performance	5 (19%)	6
2	Good performance	4 (37%)	12
3	Average performance	3 (25%)	8
4	Weak performance	2 (19%)	6
5	Very weak performance	1 (0%)	0

We may now make a comparison between the two distributions (obtained and normal).

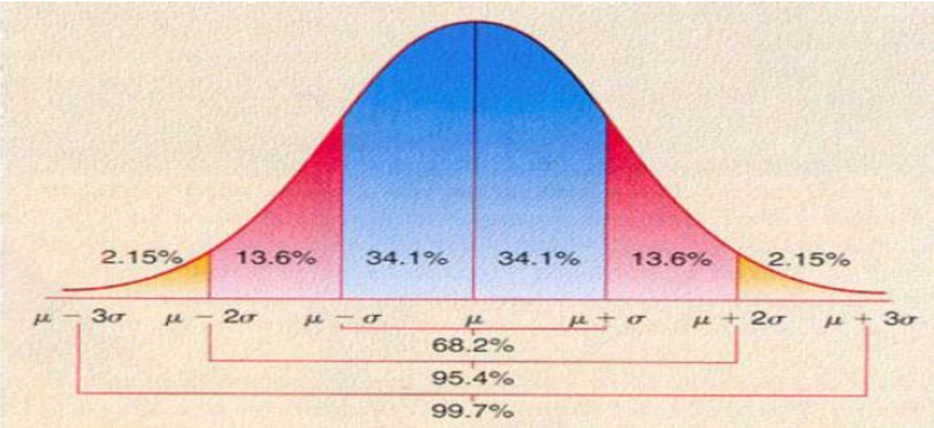

Figure 4. Reprezentation of Gaussian distribution.

Table 5. Comparison between normal and obtained distribution.

% according to the calculation (Gaussian curve)	% according to the evaluation of employees
2	19
14	37
68	25
14	19
2	0

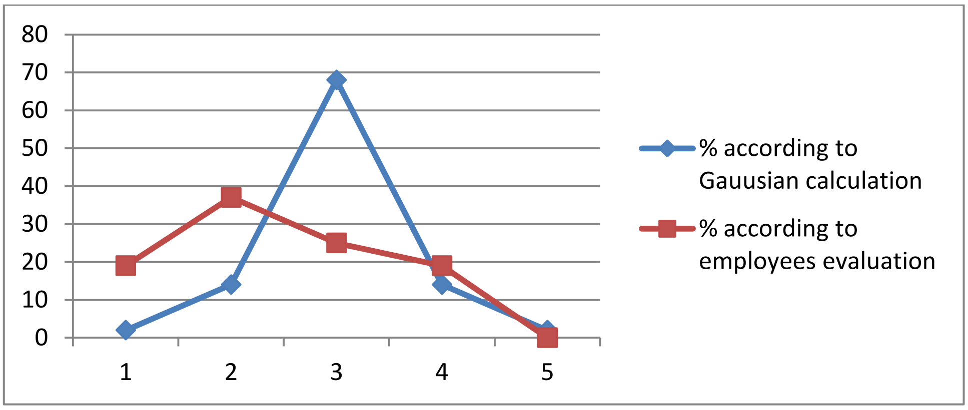

Figure 5. The representation of the two types of distributions.

Tha graphical reprezentation of our case presents a pronounced asymmetry on the left, but positive, where are prevail the good values (4-37%), the average values (3-25%), the very good (5-19%), and then the weakest (2-19%), having a longer tail to the smallest values.

As we may see from the table and from the grapfical representation, there are 12 employees situated on the scale with good performance, 8 employees on the average scale of performance and 6 employees with maximum and also weak performance.

These performances are corresponding to a binomial asymmetric distribution, represented to the limit; thus, it is symmetrical by force, as a binomial distribution, around the performance with good values (the term with the biggest probability). In conclusion, the employees performances are growing, the graphical representation departs from normal Gaussian representation.

An explanation of the movement to the left of the big averages, compared with the proper distribution, would be as a percentage of 81% of employees have achieved performance above average; according to the Gaussian calculations, good and very good performance ought to get a rate of 16%, while our calculations indicate 56% and the average performance would have to obtain 68% of employees, but our analysis shows that this group performance is only 25% of evaluated employees. Another explanation would consist in getting whatever efforts of good and very high grades in order to obtain financial benefits, such as promotion, getting higher wages, tickets paid for holidays, life and health insurance, share of profit, etc., and non-financial: public praise, rotation of the job, devolution of decision, participation in training programs and training for employees paid by the company for employees who obtained ratings between 3-4 points, etc.

A second conclusion is that the major deviations from the proper distribution demonstrates either an incorrect assessment and introduction of employees to higher performance or the analyzed collectivity have not homogeneous performances, as to be normal in a disrupted system outside or inside, but a mixture of two categories: "ready and able" or "unable and unprepared." This explains why the performance evaluation notes that the curve has two "kurtosis".

Step 3.The calculation of the indicators: skewness and kurtosis

These indicators may be determined using Excel- Descriptive statistics.

Table 6. The calculation of skewness and kurtosis.

Mean	3,5625
Standard Error	0,179254
Median	4
Mode	4
Standard Deviation	1,014015
Sample Variance	1,028226
Kurtosis	-0,99456
Skewness	-0,18099
Range	3
Minimum	2
Maximum	5
Sum	114
Count	32
Largest(1)	5
Smallest(1)	2
Confidence Level(99,0%)	0,491881

Analysis of kurtosis

Kurtosis is dimensionless statistical metric, a nondimensional quantity and quantifies the deviation from Gaussianity of an arbitrary distribution, measuring the relative peakedness or flatness of a distribution [15]. Thus, it quantifies how peaked the distribution is. Distributions with rounded peak and wide shoulders have a negative kurtosis [16].

Positive kurtosis (leptokurtic) is associated with return distribution that are more peaked in the centre but that have fatter tails. Negative kurtosis (platykurtic) reflects a relatively flat distribution and suggests that performances are all over the place,, [17].

The values it can take are: when K is bigger than 0, the distribution is leptokurtic, and the values are concentrated around the central tendency; when k is equal to 0, we have a mezokurtic distribution, normal; when k is smaller then 0, we have a flat distribution.

In our case we obtained K= - 0,99 , which significates that we have a flat distribution, and the values are dispersed in relation to the central tendency indicators.

6. CONCLUSIONS

The evaluation is conducted to: establish performance targets, assess performance in past periods, to help improve current performance, assessing training needs, assess future potential, to plan careers, to review the system of remuneration, to reward employees who perform, to meet the psychological needs, to know how good/bad is performing employees, to provide clear criteria or to promote and develop the skills needed for analysis evaluators.

Applied in good faith, fair forced distribution enables employees and generates confidence in the performance evaluation system.

Given the artificiality method is needed better training of evaluators, meaning that they must know the whole lot and have clarified the contents of each qualifier. The method proves useful when organizations have a large number of employees, but also applies to collectives low, noting that in both cases it requires flexibility and recognize the level of performance. If small groups of employees (as is in our case) are not sufficient evidence to obtain a normal distribution or certain groups of subordinates cannot fit into these percentages fixed.

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