Performance Paradigm for Excellence
A Parametric Approach

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Abstract: This study has been conducted to present a framework that showcases a performance excellence system using multiple regression model applied on weights derived from pair wise comparison matrices. The assessment criteria undertaken in this work are market esteem, leadership, business strategies and workforce. Companies or start ups can embrace the approach to strive for performance excellence and can expect to achieve performance goals by working on subtle fields. The assessment model can also irradiate the start up goals for aspiring ventures.

Index Terms - Consistency, MCDM (Multi Criteria Decision Making), Pair wise Comparisons, Multiple Regression

1. Introduction

Strong competition and emerging new innovations has spurred the need to develop strategic business plans and also to efficaciously remodel the ways of operations for start-ups as well as established enterprises. It is required to follow some parameters for performance excellence to achieve the success goals.

This article intends to set up performance paradigms for running enterprises and upcoming ventures to render business processes to become more competent and efficient to meet the compliance requirements.

Performance of an enterprise depends on high goals, good feedback processes and detailed planning. Correlation between job experience and performance was established by McDaniel, Schmidt and Hunter (1988). Kluger and DeNisi (1996) wrote an article on the effects of feedback interventions on performance measures. The relationship between performance and related action process was worked out by Frese and Sonnentag (2000). A physiological approach on success and failure of micro business owners in Africa was studied by Koop, Reu and Frese (2000).

In order to set high standards of performance measure based on assessments of established enterprises, we have employed a ranking methodology which provides weights based on different criteria viz market esteem, leadership, business strategies and workforce, using pair wise comparison matrices as given by Bagla, Gupta and Mehra (2013). The concept of pair wise comparisons had been incepted centuries ago. Borda (1781) and Condorcet (1785) introduced the concept for voting problems by using only 0 and 1 in pair wise comparison matrices. The method was substantially applied by Thorndike (1920) to tackle the classical techniques of experimental psychology. Thurstone (1927) also used pair wise comparisons for portraying social values in the society. Over the last few decades, a number of methods have been developed which use pair wise comparisons for providing weights to various criteria and alternatives. AHP proposed by Saaty (1980) was a milestone in pair wise comparisons for assigning weights. Bagla et.al (2013) cited that the calculated priorities are presumable only if the comparison matrices are consistent or near consistent.

Multiple regression is used when we want to predict the value of a variable based on the value of two or more independent variables. Multiple regression models can be used to incorporate the performance feedbacks from established enterprises and the same may be applied to plan the strategies for aspiring start ups or malfunctioning enterprises. Linear regression analysis and related methods are well demonstrated in the book by John F. (1997) and also computational procedures are exemplified in another book by John F. (2016). The presented work uses R programming interface to compute multiple regression analysis as guided by the book by John F. and Sanford W. (2011).

The paper is organized in five sections. Section 1 is introductory emphasizing the importance of groundwork for performance excellence and incorporating a brief introduction of pair wise comparisons and the regression analysis. Section 2 describes the problem under consideration by presenting a hierarchical structure of criteria for performance excellence and introduces an application. Section 3 explains the application part using proposed methodologies to provide final weights for various criteria and enterprises under consideration. The methodology is illustrated via a sample survey on six companies in Section 4. Finally we draw some conclusions, followed by giving applications for further research in section 5.

2. Problem Statement

Performance excellence model is comprised of many factors of which most important are Market esteem, Leadership, Business Strategies and Workforce.

Market Esteem is all about brand name which can fetch big business projects. Brand value is the extra money a company can make from its products or services solely because of its brand name. People are willing to pay readily for a brand and what they really purchase is brand name. Big enterprises spend huge amounts on advertising in order to build their brand name for an added market value until they mark their presence in the field.

Leadership is another key factor for performance index. Kinds of decisions taken have a major impact on company's policies and performance. A good leader can drive his company to heights; here we take the example of Tata group which was facing downfall after the voluntary retirement of Ratan Tata. He took the lead role again to regain his company's reputation.

Business strategies refer to the ground plan which outlines the core purpose of the business and the set of actions to be adopted in order to achieve the goals. Business Strategies and ethics of an enterprise are also key components of performance excellence parameter.

Skilled workforce is a means of gaining competitive advantage in the market place. Limited or untrained staff can have a devastating effect on the performance and can greatly perturb performance excellence.

With these performance parameters, the key concern is to design a model which quantifies the excellence index of the desired enterprises. Problem is to provide weights to various enterprises as per their credibility on the set of above mentioned performance parameters.

The problem of weighing of performance factors is submitted to multi criteria evaluation using methodology given by Bagla et al. (2013) explained in next section. Potentially the aspiring enterprises are to be judged on valid set of performance parameters that are crucial for excellence assessment.

Figure1 shows the developed hierarchical structure for the performance excellence model. As conflicting views may arise among different entrepreneurs in determining the most decisive criteria of evaluation, a general survey was conducted to develop the main criteria for evaluating performance excellence.

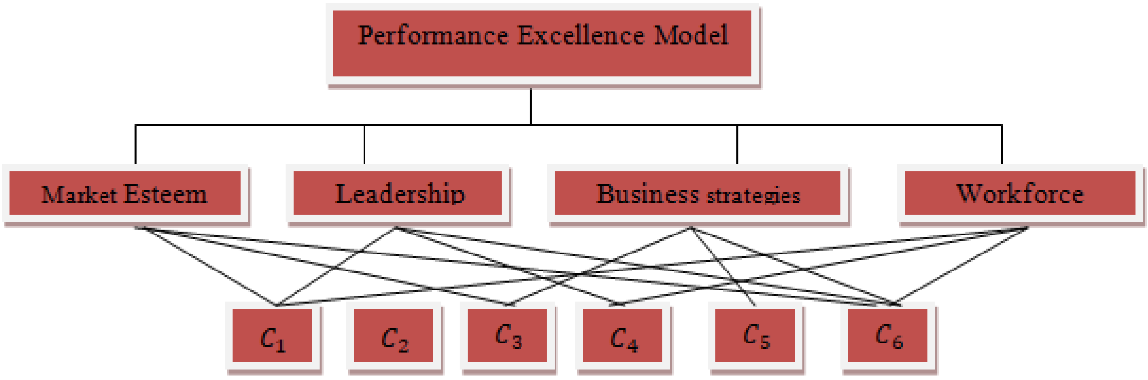

Figure 1

The criteria under performance excellence assessment model are market esteem, leadership, business strategies and workforce. Objective of the work is to gauge performance excellence of the companies C_1, C_2, C_3, C_4, C_5 and C_6 on the same set of criteria and also to set a benchmark for performance excellence for aspiring startups or malfunctioning companies.

3. Research Methodology

The proposed methodology of designing a performance excellence model for enterprises consists of four steps: (1) Identifying the criteria for performance measure; (2) weighing the criteria by using expert views; (3) evaluating the alternatives and determining the final weights to various enterprises; (4) applying multiple regression technique for attaining performance excellence to be used by aspiring establishments. The analysis may help them strengthen the effete areas to meet the performance excellence standards.

In the first Step, with the help of expertise opinion of skilled financial advisors, we have devised the affecting criteria in making performance excellence model. Significant criteria have already been discussed in section 2. To evaluate the above hierarchy using pair wise comparisons, decision makers are asked to allot rankings to the leveled criteria according to their requisite priorities. In the second step, numeric weights are provided to all the criteria using the procedure explained explicitly in section 3.1. Final weights for the third step are provided using SAW (Simple Additive Weighing) given in section 3.2. Lastly fourth step requires a relation of performance excellence of an enterprise with evaluation criteria computed using multiple regression as explained in section 3.3.

3.1Procedure to Find criteria Weights Using Pair Wise Comparisons

It is an approach to decision making that involves structuring multiple judgment criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining overall weights of the alternatives. These evaluations are converted to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. For this, the elements of a problem are compared in pairs with respect to their relative impact on the property they share in common.

A decision-maker should first rank all the n attributes to be weighed, according to their importance in the preferred domain and reorder them in an ascending order of priorities. The pair wise comparison is quantified in a matrix form in which the (i, j)th element a_{ij} is filled by the corresponding number using the scale {a/b : a, b ∈ {I+}}. If any two or more criteria are equally significant, obvious priority of one over the other is '1' using the given scale. Exercise $(n-1)$ comparisons among the consecutive criteria using the given scale. Priorities for remaining pairs (non-consecutive) can easily be computed logically as follows:

If B be prioritized *r* times to A and C is prioritize *s* times to B, then C is prioritized $r \times s$ times to A. Objective ratings to all potential pair wise comparisons can be provided in this manner and represented in a matrix form to provide weights to given set or criteria. It is conspicuous to mention here that priorities within a given pair of attributes are self-reciprocal, i.e. if B be prioritized q times to A then preference of A over B is 1/q times.

Here A is a typical pair wise comparison matrix of n alternatives representing the intensities of the expert's preference between individual pairs of alternatives

A_i versus A_j, for all i, j. $A = \begin{matrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & & a_{2n} \\ \vdots & & & \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{matrix}$

The matrix so formed is called the reciprocal matrix. This reciprocal matrix is used to calculate the local priority weight of each criterion. The local priority weight (w) is the normalized eigen vector of the priority matrix corresponding to the maximum eigen value of the matrix. For detailed reasoning of this account we refer to Ball et.al. (1994) and Bryson & Mobolurin (1994) and An interesting property of the priority matrix is that if in addition its elements satisfy the relation $a_{ij}.a_{jk} = a_{ik}$, $i \le j \le k$, the reciprocal matrix is called consistent. However in practice, Saaty (1980) introduced the concept of consistency index CI of a reciprocal matrix as the ratio $\frac{\lambda_{max}-1}{n-1}$ for measuring consistency of priority matrices, where λ_{max} and n respectively stand for the maximum eigen value and order of the reciprocal matrix. In general, a consistency ratio comes out to be nearly zero. If consistency is poor, inconsistency of judgments within the matrix has occurred and the evaluation process should therefore be reviewed and recalculated.

The procedure described by Bagla et.al (2013) results in perfectly consistent comparison matrix supported by the fact $\lambda_{max} = n$ and hence CI = 0. Eigenvector corresponding to this maximum eigen value provides the requisite criteria weights. The outcome is a prioritized weighting of each decision alternative. Geometric mean or weighted geometric mean of individual judgments may be taken to incorporate group decisions. This accomplishes aggregated matrices for the set of criteria at various levels of hierarchy. The nodes at each level are compared pair wise with respect to their contribution to the nodes above them to find their respective global weights. We rank each of the criteria in the final set by evaluating it with respect to upper level attributes separately. The evaluation process finally generates the global weights for each requisite criterion of interest. In a realistic scenario, the technique is very adaptable and can handle any number of attributes in a system. This simplification can reduce the calculation effort for the weights significantly, especially when judgment criteria are large in number and pair wise comparisons are difficult to be accomplished.

3.2 SAW (Simple Additive Weighing)

The SAW method is probably the best known and most widely used MCDM (Multi Criteria Decision Making) method. It is intuitive and easy. A score in the SAW method is obtained by contributions from each criterion.
Since two items with different measurements cannot be added, a common numerical scaling system such as normalization is required to permit addition among criteria values. The total score for each alternative can be computed by multiplying the comparable ratings for each alternative with its respective criterion weight and then adding these products over all the criteria. In general, suppose that a given MCDM problem is defined on m decision criteria and n alternatives. Furthermore, let us assume that all the criteria are beneficial criteria. That is, the higher the values are, the better it is. Next suppose that w_i denotes the relative weight of importance of the criterion C_i and p_{ij} is the normalized performance value of alternative A_j when it is evaluated in terms of criterion C_i. Then the total importance (weight) of alternative A_j, denoted as R_j is defined as follows:

$$R_j = \sum p_{ij} w_i \quad \forall j$$

3.3 Multiple Regression

Multiple regression is an extension of simple linear regression and is used when we need to predict the value of a variable (known as dependent variable) based on two or more other variables (independent variables). It is a statistical technique that simultaneously develops a mathematical relationship between two or more independent variables and a dependent variable. Equation ① describes a multiple linear regression model having n predictor variables $x_1, x_2, x_3, \dots, x_n$.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n + \epsilon \qquad \dots ①$$

The model is linear because it is linear in the parameters $\beta_0, \beta_1, \beta_2, \dots, \beta_n$.

The parameter β_0 is the intercept and the parameters $\beta_1, \beta_2, \dots, \beta_n$ are the partial regression coefficients, and ϵ is the lump sum residue (error) in the analysis.

Here Parameter β_1 denotes the change in the mean response corresponding to a unit change in x_1 when $x_2, x_3 \dots, x_n$ are held constant. Similarly the parameter β_2 gives the change in the mean response corresponding to a unit change in x_2 when $x_1, x_3 \dots,$ x_n are held constant.

Following statistics are used while conducting the regression analysis.

1. R^2: It is the coefficient of the multiple determination. It measures the strength of association between the variables.
2. F value: F test in the multiple regression is used to test the null hypothesis that the coefficient of the multiple determination in the population is equal to zero.

There are certain assumptions made to execute multiple regression analysis, some important ones are given below:

1. There must be roughly a linear relationship between the dependent (predicted) variable and the independent variables.
2. Multiple regression analysis assumes that the independent variables are not highly correlated with each other.
3. The variance of the residues (errors) should be the same at each level of the explanatory variables and also residues should not be correlated.

3.4 Computational Tools

We have used AHP calculation software by CGI for computation of weights and R programming interface for computing multiple regression.

4. Allotting Weights to Criteria and Enterprises and Thereby Applying Multiple Regression Model

A survey was conducted on selected industry experts to give their priorities to above specified performance parameters and also to various enterprises in lieu of their objective scores on specific parameters. They were solicited to rank four attributes viz. Market Esteem, Leadership, Business Strategies and Workforce in ascending order in conformance with their priorities. To evaluate the hierarchy (Figure1), they were also requested to rank the specified enterprises by virtue of their scores on each performance parameter.
The ranking awarded to the four performance parameters (Leadership, Business Strategies, Workforce and Market Esteem) in ascending order of priorities were as follows:
Business Strategies and Leadership are ranked at same level, Workforce is prioritized two times over them and Market Esteem is prioritized two times over Workforce. Allotted weights using procedure discussed in section 3.1 are (0.5, 0.125, 0.125, 0.25) as shown in Table 4.1.

Table 4.1: Prioritized Weights For Performance Parameters

Performance Parameters	Market Esteem	Leadership	Business Strategies	Workforce	Weights
Market Esteem	1	4	4	2	0.5
Leadership	1/4	1	1	1/2	0.125
Business Strategies	1/4	1	1	1/2	0.125
Workforce	1/2	2	2	1	0.25

Tables 4.2, 4.3, 4.4 and 4.5 respectively provide the priorities of specified establishments with respect to each performance parameter. Here we have taken up six companies C_1, C_2, C_3, C_4, C_5 and C_6 for surveying purpose.

Table 4.2: Prioritized Weights for Market Esteem

Market Esteem	C_1	C_2	C_3	C_4	C_5	C_6	Weights
C_1	1	1/2	¼	1/12	1/24	1/48	0.010989
C_2	2	1	½	1/6	1/12	1/24	0.021978
C_3	4	2	1	1/3	1/6	1/12	0.043956
C_4	12	6	3	1	1/2	1/4	0.131868
C_5	24	12	6	2	1	1/2	0.263736
C_6	48	24	12	4	2	1	0.527473

Table 4.3: Prioritized Weights for Leadership

Leadership	C_1	C_2	C_3	C_4	C_5	C_6	Weights
C_1	1	2	1/2	1/12	1/6	1/12	0.0298507
C_2	1/2	1	1/4	1/24	1/12	1/24	0.0149254
C_3	2	4	1	1/6	1/3	1/6	0.0597015
C_4	12	24	6	1	2	1	0.358209
C_5	6	12	3	1/2	1	1/2	0.179104
C_6	12	24	6	1	2	1	0.358209

Table 4.4: Prioritized Weights for Business Strategies

Business Strategies	C_1	C_2	C_3	C_4	C_5	C_6	Weights
C_1	1	1/6	1/6	2	1/3	2	0.0588235
C_2	6	1	1	12	2	12	0.352941
C_3	6	1	1	12	2	12	0.352941
C_4	1/2	1/12	1/12	1	1/6	1	0.0294118
C_5	3	1/2	1/2	6	1	6	0.176471
C_6	1/2	1/12	1/12	1	1/6	1	0.0294118

Table 4.5: Prioritized Weights for Workforce

Workforce	C_1	C_2	C_3	C_4	C_5	C_6	Weights
C_1	1	1/6	½	2	1/6	2	0.0625
C_2	6	1	3	12	1	12	0.375
C_3	2	1/3	1	4	1/3	4	0.125
C_4	1/2	1/12	¼	1	1/12	1	0.03125
C_5	6	1	3	12	1	12	0.375
C_6	1/2	1/12	1/4	1	1/12	1	0.03125

Table 4.6 shows normalized weights to all performance parameters and cumulative weights for all companies which have been computed using Saw (Simple Additive Weighing) explained in section 3.2.

Table 4.6: Prioritized Normalized Weights to All Performance Parameters and Companies

	Market Esteem (0.5)	Leadership (0.125)	Business Strategies (0.125)	Workforce (0.25)	Cumulative Weights
C_1	0.010989	0.0298507	0.0588235	0.0625	0.032204
C_2	0.021978	0.0149254	0.352941	0.375	0.150722
C_3	0.043956	0.0597015	0.352941	0.125	0.104808
C_4	0.131868	0.358209	0.0294118	0.03125	0.122199
C_5	0.263736	0.179104	0.176471	0.375	0.270065
C_6	0.527473	0.358209	0.0294118	0.03125	0.320002

Figure 2 shows the computation of performance excellence index using multiple regression (explained in section 3.2) on R programming interface.

```
> Companies <- c(0.032204, 0.150722, 0.104808, 0.122199, 0.270065, 0.320002)
> Mar_est <- c(0.010989, 0.021978, 0.043956, 0.131868, 0.263736, 0.527473)
> Leadership <- c(0.0298507, 0.0149254, 0.0597015, 0.358209, 0.179104, 0.358209)
> Bus_st <- c(0.0588235, 0.352941, 0.352941, 0.0294118, 0.176471, 0.0294118)
> Workforce <- c(0.0625, 0.375, 0.125, 0.03125, 0.375, 0.03125)
> relation <- lm(Companies~Mar_est+Leadership+Bus_st+Workforce)
> print(summary(relation))

Call:
lm(formula = Companies ~ Mar_est + Leadership + Bus_st + Workforce)

Residuals:
         1          2          3          4          5          6 
 7.898e-10 -2.695e-08  1.674e-08 -1.926e-09  2.232e-08 -1.097e-08 

Coefficients:
             Estimate Std. Error   t value Pr(>|t|)    
(Intercept) 3.655e-07  5.332e-08 6.854e+00   0.0922 .  
Mar_est     5.000e-01  1.425e-07 3.509e+06 1.81e-07 ***
Leadership  1.250e-01  2.147e-07 5.822e+05 1.09e-06 ***
Bus_st      1.250e-01  1.891e-07 6.611e+05 9.63e-07 ***
Workforce   2.500e-01  1.486e-07 1.683e+06 3.78e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.037e-08 on 1 degrees of freedom
Multiple R-squared:      1,	Adjusted R-squared:      1 
F-statistic: 8.952e+12 on 4 and 1 DF,  p-value: 2.507e-07
```

Figure 2

Here the performance excellence index of enterprises (represented by companies C_1, C_2, C_3, C_4, C_5 and C_6) is dependent variable, computed on four independent variables viz. Market Esteem, Leadership, Business Strategies and Workforce using multiple regression.

Summary of the analysis shows the intercept value $\beta_0 = 0.0000003655$, $\beta_1 = 0.5$, $\beta_2 = 0.125$, $\beta_3 = 0.125$ and $\beta_4 = 0.25$.

Comparing with equation ① in section 3.3

$Y = 0.0000003655 + 0.5x_1 + 0.125x_2 + 0.125x_3 + 0.25x_4$

Here Y gives performance excellence index, where x_1 denotes Market esteem, x_2 denotes Leadership, x_3 denotes Business Strategies and x_4 denotes Workforce.

Startups and existing enterprises can attain performance excellence by working on substancial areas.

In this analysis P value given in last column (Figure2) for all the parameters is less than 0.05, so all the performance factors are significant at the 5% level.

5. CONCLUDING REMARKS

This research article is pioneered to set up an exemplary course of action for performance excellence that could be extended to diversified criteria and parameters. Achieving performance excellence has never been an easy task and needs substantiate managerial decisions from conceptualization to implementation. Presented work paves the way for the technical analysis of workable areas using optimization techniques. Multiple regression analysis is very useful in predicting the performance excellence index by using predictive information of performance parameters.

Acknowledgment

I wish to acknowledge all the industry experts and contributors whom I have consulted for technical advices as well as the surveyors for providing relevance to performance excellence factors. Also I am thankful for online support from the websites:

1. http://www.isc.senshu-u.ac.jp/~thc0456/EAHP/AHPweb.html
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