THE FRIEDMAN TWO–WAY ANOVA BY RANKS APPLICATION: COMPARISON OF CHANGE FORCES

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Abstract: Every organization is confronted with forces it has to adapt in order to survive. From the company perspective, the strength of a change force is determined by its current or future impact on the company's performance. If we want to analyze an organizational change process we should start with analyzing the forces within the firms internal and external environment. The varieties and strengths of forces perceived will have the cues for further actions.

In this study two organizations from different sectors are analyzed. To measure the change forces existed within the companies' environments a five-factor change force questionnaire is conducted.

Then a nonparametric test, Friedman two-way ANOVA and its multiple comparison test is performed to compare the means of the factors obtained

Keywords: Organizational Change, Change Forces, Nonparametric Friedman Test, Multiple Comparisons

FRIEDMAN İKİ YÖNLÜ VARYANS ANALİZİ UYGULAMASI: DEĞİŞİM GÜÇLERİNİN KARŞILAŞTIRILMASI

Özet: Bütün organizasyonlar kendilerini değişime zorlayan çevresel faktörlerle karşı karşıyadırlar. Değişim güçleri adını verdiğimiz bu faktörlerin bir firmanın şimdiki ve gelecekteki performanslarına olan etkisi onların kuvvetini belli eder. Eğer örgütsel değişim sürecini incelemek istiyorsak bu incelemeye bir işletmenin iç ve dış çevresindeki faktörleri inceleyerek başlamamız doğru olacaktır. Firmaların karşı karşıya oldukları değişim güçlerinin çeşitliliği ve zorlayıcı etkileri organizasyounun gelecekteki davranışlarına ip ucu teşkil edecektir.

Bu çalışmada farklı sektörden iki firmanın karşı karşıya olduğu değişim güçlerini ölçmek için beş faktörlü değişim gücü anketi uygulanmıştır.

Çıkan sonuçları karşılaştırmak için izlenen istatistiksel yöntem parametrik olmayan Friedman iki yönlü varyans analizi ve bu teste bağlı çoklu karşılaştırma yöntemidir.

Anahtar Kelimeler: Örgütsel Değişim, Değişim Güçleri, Nonparametrik Friedman Testi, Çoklu Karşılaştırma

I. INTRODUCTION

The increasing chaotic nature of the environment, new realities of telecommunication, global networks, restructuring, mergers, and strategic alliances have caused the world around organizations ever competitive and changing very fast [1,2]. The need for knowledge about how to lead and manage organizational change rapidly, efficiently and effectively is apparent [1].

Organizational change can be defined as the adaptation of a new idea or behavior by an organization; to change is to take different actions than previously [3, 4]. Change is an alteration of status quo [5].

During status quo, an equilibrium state, why would anyone need change? The answer given to this question is change forces.

Forces of Change

Change forces come in three basic forms. First form is established trends in the socio–political, economic, technological, competitive, and organizational environments. Second form is turning point that reflects the limits to the established trends (limits to the existing resources, capacity, investment, growth) and the stimuli promoting new trends (innovation, life cycle shifts, new players) [6]. These two forms of change forces are external forces that are outside the control of the organization [5]. The last form is internal change drivers in the form of company problems and needs, plans and goals, organizational shifts, new managers, and change agents [3, 6].

From the company perspective, the strength of a change force is determined by its current or future impact on the company's performance. A strong change force creates a substantial decline in the performance of a company that is not adapted to it, and improvement in performance of a company that is adapted [6]. Different

organizations seek to deal with environmental pressures in different ways; some rely largely on reaction, others are proactive [7].

When change forces cause a disparity between actual and desired conditions, it triggers actions to reduce disparity, which is defined as reactive change [8].

It is an all too common reality to try and solve a problem by reacting after it has been created. But a much more royal strategy would be to proact and prevent the issues from manifesting [9].

Proactive change is defined as a change that occurs in the absence of recognized problems or declining performance [10].

Timing is important in change [9]. Reactive crisis fighters, who rely heavily on their ability to react and respond quickly, typically challenge of short-term problems. Crisis situations often bring out the best in people who call on their reserves of inner strengths. However, it is time-consuming, reducing the time and space available for wider strategic thinking, and consequently real growth opportunities may well be missed [7]. In the case of proactive change, the change forces have yet to affect performance. Typically, there is enough time to initiate change through the identification and analysis of market opportunities [6,10].

Reactive change is about surviving. But change isn't about surviving only; it's about thriving too. Organizations who want to position to thrive in the future rather than to survive in the present are required in turbulent markets [2]. As its not enough to gain competitive advantage but sustaining it is the problem in ever-competitive environments.

As a result there are two change strategies that can be applied by an organization. Either to wait for the forces of change to have an affect on the organizations performance and react, or scan the environment or realize the forces of change before they effect the organizational performance.

Hence it is important to measure the change forces an organization is faced with. If we can determine the type and strength of the forces effecting a firm it would be easier to determine the strategy to manage them.

II. METHOD

II.1. Sample

Two studies are conducted with two groups of data. Data were collected from two private companies one from automotive (Company 1) and the other from IT (Company 2) sector. Samples consisted of 36 and 44 employees respectively.

II.2. Instrument

The instrument used to measure the change forces is the Forces Scale of Organizational Change Questionnaire, a multi-scale questionnaire developed by the author [11].

Forces scale was developed to measure the degree employees perceive internal and external change forces. Forces scale has 22 items and respondents are asked to rate how much each item forces their organization to change on a 6 point scale where "not at all" = 1 and " definitely " = 6.

Answers are then grouped and analyzed in 5 factors: "organizational", "business inputs", "competition", "laws & regulations", and "pressure groups". The factors are the result of Principle Component Analysis that was conducted during the questionnaire development.

Table.1: Change Forces Scale

CHANGE FORCES	SAMPLE ITEMS	# of ITEMS	RELIABILITY*
Organizational	Financial position, Personnel demands	9	0.887
Business Inputs	Bargaining power of customers, Suppliers	5	0.842
Competition	Domestic competition, New entrants	4	0.818
Laws & Regulations	Domestic, International laws & regulations	2	0.760
Pressure Groups	Labor unions, Environmentalism	2	0.735

* Cronbach α results of 2001 study when the scale was developed. n = 253

Sample items and item numbers of the factors and Cronbach α reliabilities according to original study can be seen in Table.1.

II.3. Findings

After we applied the questionnaire to our samples, we first conducted Cronbach α to test the reliability, the internal consistency of the scale and its dimensions.

The result was 5 factors with reliabilities all above 0.70 (α=0.878, 0.746, 0.731, 0.867, 0.717, respectively) for Company 1. Company 2 findings were α=0.898, 0.869, 0.867, 0.658, 0.713, respectively (Table.2). Reliability of "laws & regulations" dimension was below the 0.70 level, which is considered as an acceptable alpha level in literature. But as 0.658 is close to 0.70 and since in the other sample group and in the original study α values were 0.867 and 0.760, we included this factor in our further analyses.

Table.2: Cronbach α Reliability Results

CHANGE FORCES	CRONBACH α RELIABILITY	
	Company 1	Company 2
Organizational	0.878	0.898
Business Inputs	0.746	0.869
Competition	0.731	0.867
Laws & Regulations	0.867	0.658
Pressure Groups	0.717	0.713

The findings of the questionnaire application can be seen in Table.3 and 4 for Company 1 and Company 2.

Mean of the change forces for Company 1 were mean $_{organizational\ force}$ = 29.222, mean $_{business\ input}$ = 17.722, mean $_{competition}$ = 15.583, mean $_{laws\ \&\ regulations}$ = 7.528, and mean pressure $_{group}$ = 3.806.

Table.3: Change Forces Results – Company 1

CHANGE FORCES	Mean	Std. Deviation	Minimum	Maximum	N
Organizational	29.222	8.370	12	45	36
Business Inputs	17.722	4.220	10	28	36
Competition	15.583	3.938	8	24	36
Laws & Regulations	7.528	2.624	3	12	36
Pressure Groups	3.806	2.149	2	11	36

Table.4: Change Forces Results – Company 2

CHANGE FORCES	Mean	Std. Deviation	Minimum	Maximum	N
Organizational	21.023	8.815	9	54	44
Business Inputs	17.523	7.119	5	30	44
Competition	13.227	5.818	5	24	44
Laws & Regulations	4.295	2.584	2	12	44
Pressure Groups	2.591	1.743	2	12	44

Mean of the change forces for Company 2 were mean $_{organizational\ force}$ = 21.023, mean $_{business\ input}$ = 17.523, mean $_{competition}$ = 13.227, mean $_{laws\ \&\ regulations}$ = 4.295, and mean pressure $_{group}$ = 2.591.

Yet finding out scores of factors is not enough to specify which factors existed more than the others in respondents' environments. To search the difference between ratings given to factors a statistical test is required.

Since mean scores are obtained by adding related item scores and calculating the arithmetic mean for each factor, minimum and maximum values they can get differ by the number of items each factor contains. To perform the test first variables are reorganized and each variable is divided by the number of items it contained.

This step was necessary because variables with higher item numbers would get higher values not because they are rated high but simply because they have more items.

Table.5: Change Forces Results – 6-Point Scale – Company 1

CHANGE FORCES	Mean	Std. Deviation	Minimum	Maximum	N
Organizational	3.247	0.930	1.3	5.0	36
Business Inputs	3.544	0.844	2.0	5.6	36
Competition	3.896	0.984	2.0	6.0	36
Laws & Regulations	3.764	1.312	1.5	6.0	36
Pressure Groups	1.903	1.075	1.0	5.5	36

Table.6: Change Forces Results – 6-Point Scale – Company 2

CHANGE FORCES	Mean	Std. Deviation	Minimum	Maximum	N
Organizational	2.336	0.979	1.00	6.00	44
Business Inputs	3.505	1.424	1.00	6.00	44
Competition	3.307	1.455	1.25	6.00	44
Laws & Regulations	2.148	1.292	1.00	6.00	44
Pressure Groups	1.295	0.872	1.00	6.00	44

For example, a factor with two items may be rated as "strongly agree" in both of its items and a factor with five items may be rated as "slightly disagree" in all of its items. When we convert these results to numeric values first factor gets 12 (6 x 2) and second factor gets 15 (3 x 5).

So after the conversion all of our variables get values between 1 to 6 (Table.5 and Table.6).

In our case as same employees have evaluated different change forces we are faced with matched instead of independent groups. Therefore we cannot use the two-way ANOVA since its assumptions require completely randomized experimental design, that is, independent random sample of experimental units are assigned to the treatments [12] to test the difference between forces.

That leaves us with the option of randomized block design. In general a randomized block design compares v treatments by using d blocks. In some experiments a block may consist of matched sets of experimental units [12] as in our case.

Yet when the assumptions for analyzing data collected from randomized block design are violated, any inferences derived from the ANOVA are suspect. In this situation a nonparametric procedure should be used [12,13].

Since we could not use the total scores of the factors with a range changing between 1 to 6 and the sample sizes are fairly small (n=36 and n=44) we preferred the nonparametric statistical test which do not require normality assumption as its parametric version randomized block design. That is to say the observations must be drawn from normally distributed populations.

Hence to search the difference between ratings given to factors Friedman two–way analysis of variance by ranks tests are conducted.

Friedman two–way analysis of variance by ranks test

The Friedman two–way analysis of variance by ranks tests the null hypothesis that the k repeated measures or matched groups come from the same population or populations with the same median [14].

Test statistic

The Friedman test statistic is defined as

$$F_r = \frac{12}{Nk(k+1)} \sum_{j=1}^{k} \left[R_j - \frac{N(k+1)}{2} \right]^2$$

Which is equivalent to

$$F_r = \frac{12}{Nk(k+1)} \sum_{j=1}^{k} R_j^2 - 3N(k+1)$$

Where N = number of rows (subjects)

k = number of columns (variables or conditions)

Rj = sum of ranks in j^{th} column

Decision Rule

When the number of rows and / or columns is large the statistic Fr is distributed approximately as χ^2 with degree of freedom k-1. Thus χ^2 distribution is used to determine the significance probability [14,15].

Method

For the Friedman test, the data are arranged in a table having N rows and k columns. The rows represent the subjects, and the columns represent the various conditions [15].

The data of the test are ranks. The scores in each row are ranked separately. That is, with k conditions being studied, the rank in any row rank from 1 to k [14]. If conditions have same scores in one row then average rank is assigned to the tie values [16].

Multiple Comparisons between Groups

When we obtain value of F_r is significant, it indicates that at least one of the conditions differs from at least one other condition. It does not tell the researcher, which one is different, nor it tells the researcher how many of the groups are different from each other. There is a simple procedure for determining which condition (conditions) differ[14]. That is:

$$\left| \overline{R}_u - \overline{R}_v \right| \geq z_{\alpha / k(k-1)} \sqrt{k(k+1)/6N}$$

Where $\overline{R}$ = average ranks
    k = number of variables or conditions
    N = number of cases or subjects

If the difference between the average ranks exceeds the corresponding critical value given in the above equation then we may conclude that the two conditions are different.

Results of The Friedman Test

We conducted Friedman test to see if there were any differences between the magnitude of five factors of change forces scale and to find out which factors forced respondents' organizations to change more. We used the SPSS statistics software in our computations.

At 99 % confidence interval we found a significant difference between five factors with χ^2= 69.827 and p=0.000 in Company 1 and χ^2= 101.168 and p=0.000 in Company 2 (See Table.7 and 8).

Table.7: Friedman Test Result –Company 1

CHANGE FORCES	Mean Rank
Organizational	2.778
Business Inputs	3.514
Competition	3.847
Laws & Regulations	3.639
Pressure Groups	1.222
N	36
Chi-Square	69.827
df	4
Asymp. Sig.	0.000

As the findings of the analyses for both samples were significant we need to conduct multiple comparison tests to see from which groups these significant results come from. Multiple comparison tests for Friedman two-way ANOVA does not exist within the statistics software package. Hence we had to calculate them using the formula given above.

Table.8: Friedman Test Result –Company 2

CHANGE FORCES	Mean Rank
Organizational	2.966
Business Inputs	4.170
Competition	4.080
Laws & Regulations	2.386
Pressure Groups	1.398
N	44
Chi-Square	101.168
df	4
Asymp. Sig.	0.000

When we performed multiple comparison tests in Company 1 (See Table.9) we found there was no difference between "competition" and "laws and regulations", "competition" and "business inputs" and "laws and regulations" and "business inputs". Yet "competition" was perceived more than "organizational" and "pressure groups" found to be the least perceived force than all other four forces at 5% significance level (Mean ranks of change forces were 3.85, 3.64, 3.51, 2.78, 1.22 in the order of magnitude)

In company 2 (See Table.10) "business inputs" is perceived more than "organizational", "laws and regulations" and "pressure groups" and "competition" is again perceived more than "organizational", "laws and regulations" and "pressure groups", but there is no significant difference between "business inputs" and "competition" (α = 0.05).

Table.9: Multiple Comparison Tests–Company 1

	Mean ranks	Competi-tion 3.85	Laws & Re gulations 3.64	Business Inputs 3.51	Organiza-tional 2.78	Pressure Groups 1.22
Competition	3.85	–				
Laws & Regulations	3.64	0.21	–			
Business Inputs	3.51	0.34	0.13	–		
Organizational	2.78	1.07*	0.86	0.73	–	
Pressure Groups	1.22	2.63*	2.42*	2.29*	1.56*	–

N= 36
critical difference is 1.046 where alpha is 0.05
* difference is more than or equal to the critical difference which means difference is significant

Table.10: Multiple Comparison Tests–Company 2

	Mean ranks	Business Inputs 4.17	Competi-tion 4.08	Organiza-tional 2.97	Laws & Re gulations 2.39	Pressure Groups 1.40
Business Inputs	4.17	–				
Competition	4.08	0.09	–			
Organizational	2.97	1.20*	1.11*	–		
Laws & Regulations	2.39	1.78*	1.69*	0.58	–	
Pressure Groups	1.40	2.77*	2.68*	1.57*	0.99*	–

N= 44
critical difference is 0.946 where alpha is 0.05
* difference is more than or equal to the critical difference which means difference is significant

"Pressure groups" also perceived less than "organizational" and "laws and regulations" at 95 % confidence interval. Yet there is no significant difference between "organizational" and "laws and regulations" (Mean ranks of change forces were 4.17, 4.08, 2.97, 2.39, 1.40 in the order of magnitude)

III. DISCUSSION and CONCLUSION

Every organization is confronted with forces it has to adapt in order to survive. Forces may be internal, external or both. The strength and varieties of change forces differ depending on the industry and the company structure. The organizations differ in the way they respond to these forces. Even within the same industry organizations may perceive forces differently and take different actions to adapt.

Therefore if we want to analyze an organizational change process we should start with analyzing the forces within the firms internal and external environment. The varieties and strengths of forces perceived will have the cues for further actions.

In our study we analyzed two different companies from different industries and found in both firms "pressure groups" had significantly no effect.

In company 1, which is in automotive industry "competition", "business inputs" and "laws & regulations" had more force on the organization, but their strengths were not significantly different from each other.

For company 2 from IT sector "competition", "business inputs" were the forces that effect the organization more. Unlike the other company "laws & regulations" had significantly low strength. Hence we can say "competition" and "business inputs" were the major change forces for our samples.

Yet when we look at the magnitudes of the change forces even for change force dimensions that were significantly higher than others mean values were less than four in a six-point interval, which we conclude as moderate strength.

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