JOURNAL
OF
APPLIED
QUANTITATIVE
METHODS

ORDINAL REGRESSION TO ANALYZE EMPLOYEES' ATTITUDES TOWARDS THE APPLICATION OF TOTAL QUALITY MANAGEMENT

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Abstract: The ordinal regression method was used to model the relationship between the ordinal outcome variable, e.g. different levels of employees' attitude regarding the overall working experience in the application of Total Quality Management (TQM) in University of Bahrain (UOB), and the explanatory variables concerning demographics and employees working environment in UOB. The outcome variable for employees' attitudes was measured on an ordered, categorical five-point Likert scale. The major decisions involved in the model building for ordinal regression were deciding which explanatory variables should be included in the model and choosing the link function (e.g. logit link, probit link, negative log-log link and complementary log-log link) that demonstrated the model appropriateness. In addition, the model fitting statistics, the accuracy of the classification results and the validity of the model assumptions, e.g., parallel lines, were essentially assessed for selecting the best model. One of our main finding is that suitable environment for development of staff capabilities and opportunities to train on the skills of solving routine and non-routine problems are highly significant with the employee's attitude toward the application of TQM.

Key words: Generalized linear model; regression; quality management.

Introduction

Total Quality Management, TQM, is a management philosophy that seeks to integrate all organizational functions to focus on meeting customer needs and organizational objectives. The management and employees become involved in the continuous improvement of the production of goods and services. Although originally applied to manufacturing operations, and for a number of years only used in that area, TQM is now becoming recognized as a generic management tool, just as applicable in service and public sector organizations. TQM can be a powerful technique for unleashing employee creativity and potential, reducing bureaucracy and costs, and improving service to clients and the community; see, Evans and Lindsay (2008). Unfortunately, in practice, employees' attitudes are usually not evaluated unless their performance is unsatisfactory. So long as employees' performance is going well, attitudes in themselves may not be closely examined on the assumption that interest and cooperation are probably at acceptable levels. It is when the performance of the employees fall short of that expected by the top manager that the latter is apt to start looking into attitudinal factors that may underlie the poor showing that can eventually affect other people performance; see; Martin (1993).

In this study, the ordinal regression method was used to model the relationship between the ordinal outcome variable, e.g. different levels of employees' attitude regarding the overall working experience in the application of Total Quality Management at University of Bahrain (UOB), and the explanatory variables concerning demographics and employees working environment at UOB. The outcome variable for employees' attitudes was measured on an ordered, categorical, and five-point Likert scale- 'strongly disagree', 'disagree', 'neural', 'agree' and 'strongly agree'. It is implausible to assume the normality and homogeneity of variance for ordered categorical outcome. Thus, the ordinal regression model becomes a preferable modeling tool that does not assume the normality and constant variance, but require the assumption of parallel lines across all levels of the categorical outcome. Explanatory variables included four demographic levels, e.g., gender, age, experience and education level and 21 questionnaire items related to the awareness of the concepts of TQM, support of top management for TQM, team work policy, and training programs at UOB, see Figure 1. Regression methods such as linear, logistic, and ordinal regression are useful tools to analyze the relationship between multiple explanatory variables and clients' attitude.

The ordinal regression method is capable of allowing researcher to identify explanatory variables related to training programs, team work policy and support services that contribute to overall employees' attitude toward the application of TQM. The ordinal regression also permit researcher to estimate the magnitude of the effect of the explanatory variables on the outcome variable. The major decisions involved in the model building for ordinal regression were deciding which explanatory variables should be included in the model and choosing the link function (e.g. logit link, probit link and complementary log-log link) that demonstrated the model appropriateness. The study results could lead to a better understanding of the college programs and services from employees' perspectives; see, Staus (2008) and Hales and Chakavorty (2006).

The primary focus of the study was the formulation of the ordinal regression model, the application of ordinal regression analysis, and the interpretation of study results. The employees' attitude questionnaire was analyzed by the ordinal regression method to achieve the four study objectives:

1. To identify significant explanatory variables that influenced the overall employees' attitude;
2. To estimate thresholds (i.e. constants) and regression coefficients;

3. To describe the direction of the relationship between the explanatory variables and the overall employees' attitude based on the sign (+ and -) of regression coefficients; and

4. To perform classifications for all attitude levels of the overall employees experience, and subsequently evaluate the accuracy of the classification results.

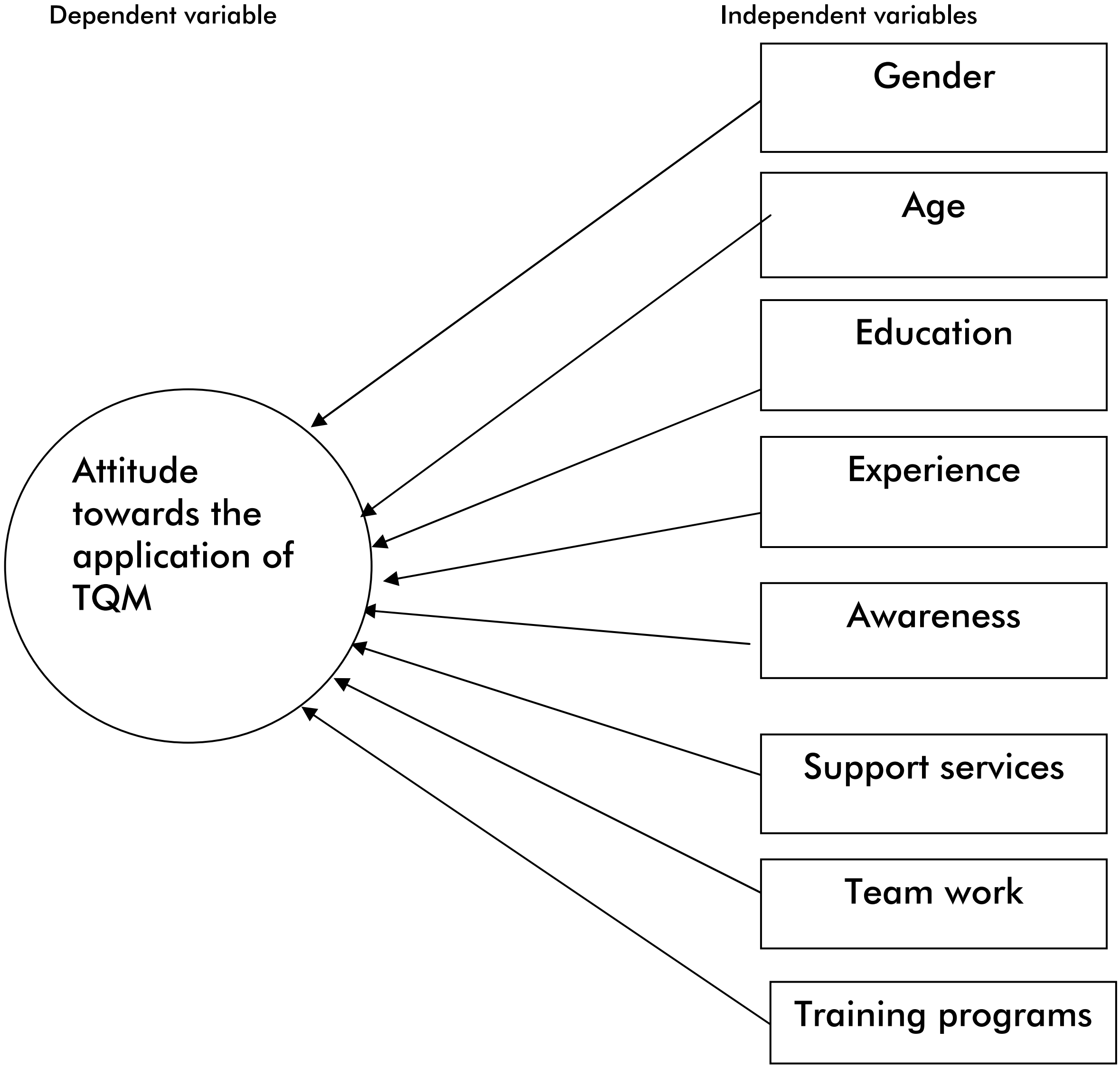

Figure 1: The model for employee's attitude towards the application of TQM

The ultimate goal of the study was to make recommendations to enhance the awareness of the concepts, support services, team work policy, and training programs as appropriate in the light of research findings.

To understand the principle of the class of generalized linear model; see, McCullagh and Nelder (1989) and Bender and Benner (2000) let us first consider a binary response variable Y. For simplicity, we consider only one explanatory factor X (binary or continuous). The question of an investigator may then be whether X has an effect on Y. As Y itself has only two values ($y=1$=yes or $y=0$=no) we analyze whether the probability of an event $\pi(x) = P(Y=1|X=x)$ is associated with X by means of an appropriate model; see, Cox and Snell (1989). The class of generalized linear models in this case is given by

$$f[\pi(x)] = \alpha + \beta x$$

Where f is an appropriate function (called link function), α is the intercept, and β is the regression coefficient of X. In the case of $m \geq 2$ explanatory factors $X_1, \ldots, X_m$ is replaced by linear combination, $\beta_1 x_1 + \cdots + \beta_m x_m$. For the analysis of binary and ordinal response data the following two link functions have been widely used

1. The logit link: $f(\pi) = \log[\pi(1-\pi)]$
2. The complementary log-log link: $f(\pi) = \log[-\log(1-\pi)]$

Grouped continuous model

Let Y be a categorical response variable with $k+1$ ordered categories where

$$\pi_j(x) = P(Y = j|X)$$

be the probability for the realization of $Y = j$, $j = 0,1, \ldots, k$ and the cumulative probabilities

$$\gamma_j(x) = P(Y \geq j|X)$$

The class of grouped continuous model is obtained by the generalized linear model in which the cumulative probabilities are used instead of π

$$f[\gamma_j(x)] = \alpha_j + \beta x, \qquad j = 1, \ldots, k$$

Note that it is assumed that for the considering link function f the corresponding regression coefficients are equal for each cut-off point j. The adequacy of this equal slopes assumption has to be evaluated carefully before this model can be applied.

In ordinal regression analysis, there are link functions, e.g., logit and cloglog links, are used to build specific models. There is no clear cut method to distinguish the preference of using different link functions. However, the logit link is generally suitable for analyzing the ordered categorical data evenly distributed among all categories. The cloglog link may be used to analyze the ordered categorical data when higher categories are more probable; see, Bender and Benner (2000).

The ordinal regression model may be written in the form as follows if the logit link is applied

$$f[Y_j(X)] = \log\left\{\frac{\gamma_j(x)}{1-\gamma_j(x)}\right\} = \log\left\{\frac{P(Y \leq x_j|X)}{P(Y > x_j|X)}\right\} = \alpha + \beta X,\ j = 1,2, \ldots, k-1$$

and

$$Y_j(X) = \frac{e^{\alpha+\beta X}}{1+e^{\alpha+\beta X}},$$

where j indexes the cut-off points for all categories (k) of the outcome variable. If multiple explanatory variables are applied to the ordinal regression model, βX is replaced by the linear combination of $\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p$. The function $f[\gamma_j(X)]$ is called the link function that connects the systematic components (i.e. $\alpha_j + BX)$ of the linear model. The alpha α_j represents a separate intercept or threshold for each cumulative probability. The threshold and regression coefficients are unknown parameters to be estimated by means of the maximum likelihood method, see, Winship (1984), Bender and Benner (2000) and Long (2003).

Methodology

Survey data were collected from a questionnaire which distributed for a random sample of employees at UOB working at different departments. We distributed 201 questionnaires and the return questionnaire was 180. The questionnaire items consisted of the employees' attitude towards the application of TQM, and four demographic such as, gender, age, experience and education levels and 21 questionnaire items concerned the application of TQM.

The 21 items were classified into four predetermined factors- the awareness of the concepts of TQM, support of top management for TQM, team work policy, and training programs at UOB. Factor I- awareness included items such as top manager has awareness of the concept of TQM (R1) and top manager continuously familiarizes the employees with TQM advantages (R2). Factor II- support of top management included items such as the qualification staff to apply TQM (R3), suitable environment for development of staff capabilities (R4), participation of the staff to improve performance quality (R5), analysis organization problems (R6) and set the suitable solutions (R7), concerned with complaints and suggestions (R8), encourage open door policy (R9), encourage staff in participation in decision making process and study on the who affected by decisions (R10). Factor III- team work policy included items such as focus on team work rather than individual performance (R11), performance evaluation is carried out through team work performance rather than individual performance (R12), and group spirit (R13). Factor IV- training programs included items such as high priority for Training (R14), training programs aims to insure the important of quality (R15), the level of efficiency and type of training has direct relationship with improvement of quality of performance (R16), the training programs include the explanation of assigning the duties and tasks of concern individuals (R17), employees are trained on the modern techniques and skills (R18), there is follow up for new recruitments (R19), opportunities to train on the skills of solving routine and non-routine problems (R20), necessary training for the process of improving quality for support an commitment (R21).

The high internal consistency for the survey instrument might be demonstrated based on the alpha reliability, all items combined 0.83 (21 items), factor I 0.79, factor II 0.81, factor III 0.75 and factor IV 0.74.

The major decisions involved in constructing the ordinal regression models where deciding what explanatory variables had more effect on the dependent variable and choosing the link functions that would be good to fit the model.

There are many of the link function which is a transformation of the cumulative probabilities that allows estimation of the model. Five link functions are summarized in Table 1; see, Staus (2008).

Table 1: The link function and its typical application

Function	Form	Typical application
Logit	$\log\left(\frac{x}{1-x}\right)$	Evenly distributed categories
Complementary log-log	$\log(-\log(1-x))$	Higher categories more likely
Negative log-log	$-\log(-\log(x))$	Lower categories more likely
Probit	$F^{-1}(x)$	Variable is normally distributed
Cauchit (inverse Cauchy)	$\tan(\pi(x-0.5))$	Variable has many extreme values

Study Results

Constructing ordinal regression model entails several decisions. First, of course, we need to identify the ordinal outcome variable. Then, we need to decide which predictors to use for the location component of the model. Finally, we need to decide which link function gives good fits for our data. We use SPSS package in our analysis; see Lin (2007) and Chen and Hughes (2004) for details. To choose a link function, it is helpful to examine the distribution of values for the outcome variable. We create the histogram for the dependent variables to show the distribution of catogries of employee attitude towards application of TQM. The bulk of cases are in the lower categories, especially categories 1 (very disagree) and 2 (disagree). For this reason, we will begin with the negative log-log link function, since that function focuses on the lower outcome categories.

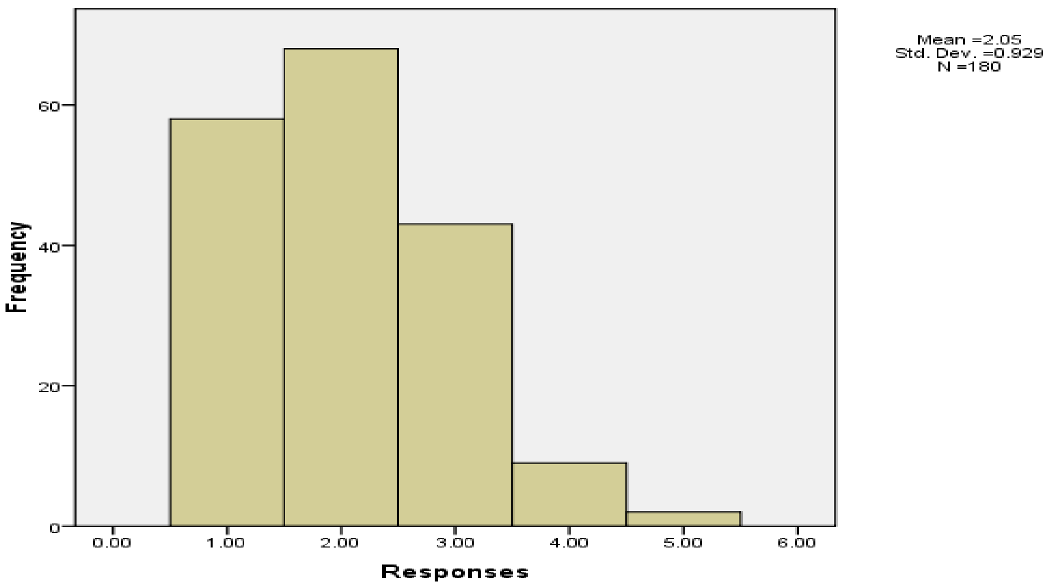

Figure 1: The distribution of employee attitude towards application of TQM

Before we start looking at the individual predictors in the model, we need to find out if the model gives adequate predictions. Therefore, we can examine the model fitting information Table 2.

Table 2: Model fitting information

Model	-2 Log likelihood	Chi-Square	df	Sig.
Intercept only	2152.34			
Final	1432.51	335.63	25	.000

Link function: negative Log-Log

The significant chi-square statistic indicates that the model gives a significant improvement over the baseline intercept-only model. This basically tells us that the model gives better predictions than if we just guessed based on the marginal probabilities for the outcome categories.

The Goodness-of-Fit is given in Table 3. This table contains Pearson's chi-square statistic for the model and another chi-square statistic based on the deviance. These statistics are intended to test whether the observed data are inconsistent with the fitted model. If they are not-the significance values are large-then we would conclude that the data and the model predictions are similar and that you have a good model. The large value for significant shows we have a good model

Table 3: Goodness of fit

	Chi-square	df	Sig.
Pearson	146.15	679	1.000
Deviance	90.08	679	1.000

Link function: Negative Log-Log

In the linear regression model, the coefficient of determination, R^2, summarizes the proportion of variance in the dependent variable associated with the predictor (independent) variables, with larger R^2 values indicating that more of the variation is explained by the model. For regression models with a categorical dependent variable, it is not possible to compute a single R^2 statistic that has all of the characteristics of R^2 in the linear regression model, so these approximations are computed instead. The following methods are used to estimate the coefficient of determination. Cox and Snell (1989) (R^2) is based on the log likelihood for the model compared to the log likelihood for a baseline model. However, with categorical outcomes, it has a theoretical maximum value of less than 1, even for a "perfect" model. Nagelkerke (1991) (R^2) is an adjusted version of the Cox & Snell that adjusts the scale of the statistic to cover the full range from 0 to 1. McFadden (1974) (R^2) is another version, based on the log-likelihood kernels for the intercept-only model and the full estimated model. The model with the largest R^2 statistic is "best" according to this measure.

Table 4 shows these values which indicate the fitting model is good according to these measures.

Table 4: pseudo R^2

Cox and Snell	0.722
Negelkerke	0.83
McFadden	0.83

The next step is to examine the predictions generated by the model. However, what we are probably most interested in is how often the model can produce correct predicted categories based on the values of the predictor variables. We construct a classification table-also called a confusion matrix-by cross-tabulating the predicted categories with the actual categories. From Table 5 the model seems to be doing good of predicting outcome categories, for categories-category 1 (strongly disagree) the models correctly classifies 91.4%, category 2 (disagree) classifies 88.85%, the category 3 (neural) classifies 79%, the category 4 (agree) classifies 89% and the category 5 (strongly agree) classifies 100%.

Table 5: Responses against predicted responses

Responses		Predicted responses catogries strongly disagree	Disagree	Neural	agree	Strongly agree	Total
Strongly disagree	Count	53	5	0	0	0	58
	%within	91.4%	8.6%	0%	0%	0%	100%
Disagree	Count	7	59	1	1	0	68
	%within	8.7%	88.8%	1.5%	1.5%	0%	100%
Neural	Count	2	6	34	1	0	43
	%within	4.6%	14%	79%	2.3%	0%	100%
Agree	Count	0	0	1	8	0	9
	%within	0%	0%	11%	89%	0%	100%
Strongly agree	Count	0	0	0	0	2	2
	%within	0%	0%	0%	0%	100%	100%
Total	Count	62	70	36	10	2	180
	%within	34%	39%	20%	5.5%	1%	100%

For our models, the test of parallel lines can help you assess whether the assumption that the parameters are the same for all categories is reasonable. This test compares the estimated model with one set of coefficients for all categories to a model with a separate set of coefficients for each category. We see from Table 6 that the assumption is plausible for this problem where the observed significant level is large.

Table 6: Test of parallel line

Model	-2Log Lik.	Chi-Square	df	Sig.
Null Hypothesis	3.793			
General	2.90	1.887	75	0.89

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

The parameter estimates are given in Table 7. Also, Table 7 summarizes the effect of each predictor. The sign of the coefficients for covariates and relative values of the coefficients for factor levels can give important insights into the effects of the predictors in the model. For covariates, positive (negative) coefficients indicate positive (inverse) relationships between predictors and outcome. An increasing value of a covariate with a positive coefficient corresponds to an increasing probability of being in one of the "higher" cumulative outcome categories. For factors, a factor level with a greater coefficient indicates a greater probability of being in one of the "higher" cumulative outcome categories. The sign of a coefficient for a factor level is dependent upon that factor level's effect relative to the reference categories.

Table 7: Explanatory variables associated with the attitude towards the application of TQM based on the ordinal regression model with negative log-log link

Item name	Regression coefficient	p-value	Item name	Regression coefficient	p-value
Const1	20.11	0	R8	0.917	0.001
Const2	27.46	0	R9	0.083	0.793
Const3	39.37	0	R10	0.667	0.021
Const4	51.30	0	R11	0.467	0.067
Gender	-0.48	0.231	R12	0.323	0.113
Age	0.057	0.045	R13	0.662	0.015
Education	-0.424	0.349	R14	0.253	0.203
Experience	-0.131	0.012	R15	0.005	0.985
R1	-.036	0.877	R16	0.609	0.051
R2	0.938	0.003	R17	0.674	0.033
R3	0.633	0.006	R18	0.483	0.081
R4	1.738	0	R19	0.745	0.014
R5	-0.696	0.021	R20	1.129	0
R6	0.898	0.005	R21	-0.136	0.555
R7	0.668	0.027			

The significance of the test for Age is less than 0.05, suggesting that its observed effect is not due to chance. Since its coefficient is positive, as age increases, so does the probability of being in one of the attitude of account status. Also, experience has opposite effect where it estimates by negative. By contrast, Gender and education adds little to the model.

For factor I- awareness we find that the awareness of the concepts (R1) is not significant while familiarize the employees with TQM advantages (R2) is significant.

For factor II- support of top management we find that qualification staff to apply TQM (R3), suitable environment for development of staff capabilities (R4), participation of the staff to improve performance quality (R5), analysis organization problems (R6) and set the suitable solutions (R7), concerned with complaints and suggestions (R8) and encourage staff in participation in decision making process and study on the who affected by decisions (R10) are significant while encouraging open door policy is not significant (R9).

Factor III- team work policy we find that focusing on team work rather than individual performance (R11) is not slightly significant. It is worth keeping such a variable in the model, since the small effects of each category accumulate and provide useful information to the model. But the performance evaluation is carried out through team work performance rather than individual performance (R12) is not significant, while group spirit (R13) is significant.

Factor IV- training programs we find that high priority for Training (R14), training programs aims to insure the important of quality (R15) and necessary training for the process of improving quality for support an commitment (R21) are not significant while the level of efficiency and type of training has direct relationship with improvement of quality of performance (R16), the training programs include the explanation of assigning the duties and tasks of concern individuals (R17), employees are trained on the modern techniques and skills (R18), there is follow up for new recruitments (R19) and opportunities to train on the skills of solving routine and non-routine problems (R20) are significant.

Note that the participation of the staff to improve performance quality (R5) is the only variable which is significant and had a negative coefficient (effect). Also, suitable environment for development of staff capabilities (R4) and opportunities to train on the skills of solving routine and non-routine problems (R20) are highly significant.

Recommendations

From above results we recommend the following:

- The establishment of an independent administration of TQM.
- Building suitable environment for development of staff capabilities.
- Giving opportunities to train on the skills of solving routine and non-routine problems.
- Focus on the importance of employee's participation and their effective role.
- Forming the work team (consideration should be given to careful selection of those individuals who are highly concerned and interested in the process of performance improvement).
- Working for facilitating some of the obstacles of applying TQM.
- Giving more concern for the development of complains and suggestion boxes.

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