ORIGINAL RESEARCH

# A Statistical Model to Determine the Relationship between Employee Supervisor Characteristics and Overall Satisfaction in Dental Departments in Saudi Arabia

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## Abstract

**Aim and objective:** An exploratory study was undertaken to determine the relationship between supervisor characteristics and overall satisfaction with supervisors as perceived by the employees of dental departments in hospitals in Saudi Arabia.

**Materials and methods:** We conducted a survey that included six questions designed to measure the overall performance of a supervisor, as well as questions that were related to specific activities involving interactions between supervisors and employees indental departments of 30 hospitals that were randomly selected. At least 35 employees and one supervisor in each dental department were interviewed. Initially, six questionnaire items were chosen as possible explanatory variables. There are two broad types of variables included in this study. Variables $X_1$ (handles employee complaints), $X_2$ (does not allow for special treatment), and $X_5$ (too critical of poor performance) relate to direct interpersonal relationships, i.e., direct connection between the employee and supervisor, whereas variables $X_3$ (opportunity to learn new things) and $X_4$ (raises based on performance) are of a less personal nature and relate to the job as a whole, i.e., indirect relationship between employees and their supervisor. Variable $X_6$ (rate of advancing to better jobs) is not a direct evaluation of the supervisor, but serves more as a general measure of how the employee perceives his or her own progress in the hospital.

**Results:** Using regression analysis, we observed that only $X_1$ (handles employee complaints) and $X_3$ (opportunity to learn new things) have an impact on response Y (overall rating of job being done by supervisor). There is a strong positive relationship between $X_1$ and Y and also between $X_3$ and Y.

**Conclusion:** Therefore, when the supervisor listens and handles employee complaints and gives employees the opportunity to learn new things, the supervisor becomes favorable.

**Clinical significance:** The relationship between supervisor characteristics and overall satisfaction with supervisors as perceived by the employees of dental departments has not been studied. An understanding of this relationship is valuable to improve employee–supervisor relations, which can improve the overall functioning of hospitals.


**Keywords:** Dental departments, Employee satisfaction, Exploratory study, Hospitals, Multiple linear regression, Statistical model, Survey analysis.

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## Introduction

In the modern workplace, especially in hospitals, subjective performance evaluations are both common and controversial.[1] Firms use these evaluations as indicators of employee performance and skills. Performance ratings affect employee compensation, task assignment, promotions, and even retention.[2] However, the ratings are also affected by the subjectivity of the rater, namely, that of the supervisor of an employee.[3] A wide variation has been observed in how supervisors rate equivalent behavior. Furthermore, supervisors differ in their ability to manage subordinates, which affects how subordinates perform on the job. These differences can possibly influence the performance ratings received by the subordinates. However, little is known about the extent and drivers of heterogeneity in the ratings received across supervisors, the degree to which firms are informed about any heterogeneity, and the impact of such heterogeneity on the careers of workers.[4]

If supervisors give different ratings for the same underlying performance, then the performance management system will be ineffective.[5] Firms will not be able to use performance evaluations to determine incentives. As a result, they may resort to counteract any heterogeneity by using forced curves or other rules to restrict the extent of discretion supervisors can have when rating subordinates.[6] However, such policies could interfere with the way supervisors manage their teams unless heterogeneity in ratings arises from real differences in a supervisor's ability to elicit output. Firms are very interested to learn about these differences, so as to reward higher effort.[1]

Lazear et al. explores how productivity varies across supervisors who are lower in the firm hierarchy. They exploit the daily rotation of line managers in a low-skilled service task (transactions per hour) to estimate variation among the productivity of subordinates associated with these managers.[6] In contrast to their setting, we

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studied employee satisfaction with their supervisor, of clerical employees performing complex tasks in different hospital organizations, for whom objective measures of performance are intrinsically difficult to achieve. To do so, we tried to estimate a model of behavior when information is imperfect. Our analysis sought to exploit both objective and subjective measures of productivity, as well as worker and supervisor pay, and career outcomes within the firm.

## Materials and Methods

We used data that were collected from our survey questionnaire with six questions that was administered in various hospitals in Saudi Arabia to demonstrate the results of standard regression analysis. This survey of clerical (administrative) employees of various hospital organizations included questions related to employee satisfaction with their supervisors. There was a question designed to measure the overall performance of a supervisor, as well as questions that were related to specific activities involving interactions between a supervisor and an employee. We randomly selected 30 hospitals. In each of the selected hospitals, the data were collected in the dental department (hence a total of 30 dental departments). We interviewed at least 35 employees and one supervisor in each dental department. The data collectors interviewed each employee and recorded their response.

Six questionnaire items were chosen as possible explanatory variables. Table 1 gives the description of the variables in the study. As can be seen from the list, there are two broad types of variables included in the study. Variables $X_1$,$X_2$,$X_3$ and $X_5$ relate to direct interpersonal relationships between an employee and a supervisor, whereas variables $X_3$ and $X_4$ are of a less personal nature and relate to the job as a whole. Variable $X_6$ is not a direct evaluation of the supervisor, but serves more as a general measure of how the employee perceives his or her own progress at work.

For the analysis, the data were generated from the response of individual employees to the survey questionnaire items. On any item, the response ranged from 1 (very satisfactory) through 5 (very unsatisfactory), respectively. We collapsed the response scale to two categories to create a dichotomous index to each item. {1,2} is to be interpreted as a favorable response, while {3,4,5} indicates an unfavorable response. The data to be used in the analysis, given in Table 1, were obtained by aggregating responses for departments to get the proportion of favorable responses for each item for each department. The resulting data therefore consist of one observation for each department and 30 observations on seven variables. There were six explanatories variable $X_1$:$X_6$ and one response variable ($Y$: Overall rating of job being done by the supervisor). We took the average of favorable response for all employees. Therefore, we have seven variables and 30 averages for 30 departments. We refer to this dataset as the dental supervisor performance data. An R package was developed to analyze the performance of the supervisor. The R code can be provided upon request.

**Table 1:** Description of variables in supervisor performance data

| *Variables* | *Description* |
|---|---|
| Y | Overall rating of job being done by supervisor |
| $X_1$ | Handles employee complaints |
| $X_2$ | Does not allow for special treatment |
| $X_3$ | Opportunity to learn new things |
| $X_4$ | Raises based on performance |
| $X_5$ | Too critical of poor performance |
| $X_6$ | Rate of advancing to better jobs |

## Results

In this study, we do not consider each question in the questionnaire separately; rather, we consider the main effect of all questions. Therefore, we use multiple regression analysis. In multiple regression analysis, a huge task is to check for violations of the multiple linear regression model assumptions.[7] This includes checking for linearity assumption, normality assumption, presence of outliers and influential observations, multicollinearity, and nonconstant variance. A violation of the linearity assumption can be determined using scatter plots, or by plotting observed versus predicted values or residuals versus predicted values. From Figure 1, it is obvious that there is no violation because the plot is structure-less (no pattern). A normal Q-Q plot of the standardized residuals can be used to check for violations of the assumptions of normality. In Figure 2, the points lie along the diagonal line, which suggests that the normality assumption is not violated.

A residual plot can be used to detect outliers and influential observations. Also, influential observations can be detected using leverage values[8] or Cook's distance[9] (Fig. 3). Using the formula influential points: $(3^{*}p - 1)/n$, the critical value is: 0.20. There are some observations (14,18,24) that have a centered leverage value larger than 0.20. It would be important to investigate these

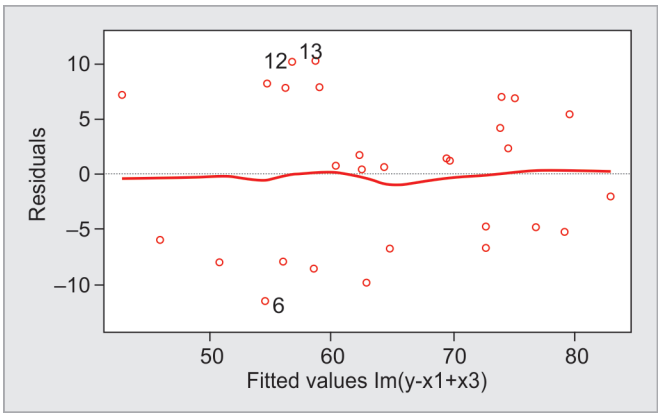



**Fig. 1:** Scatter plot to determine violation of linearity assumption

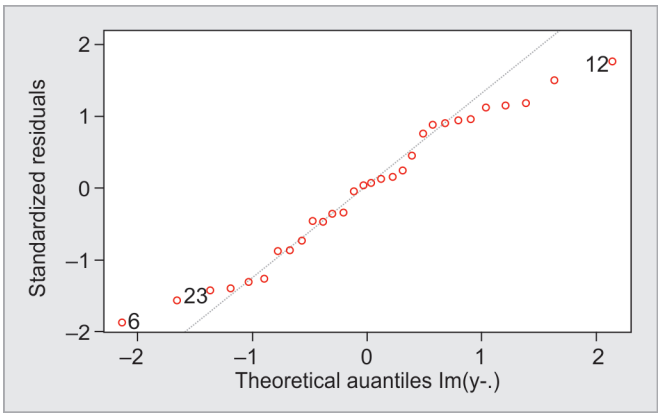
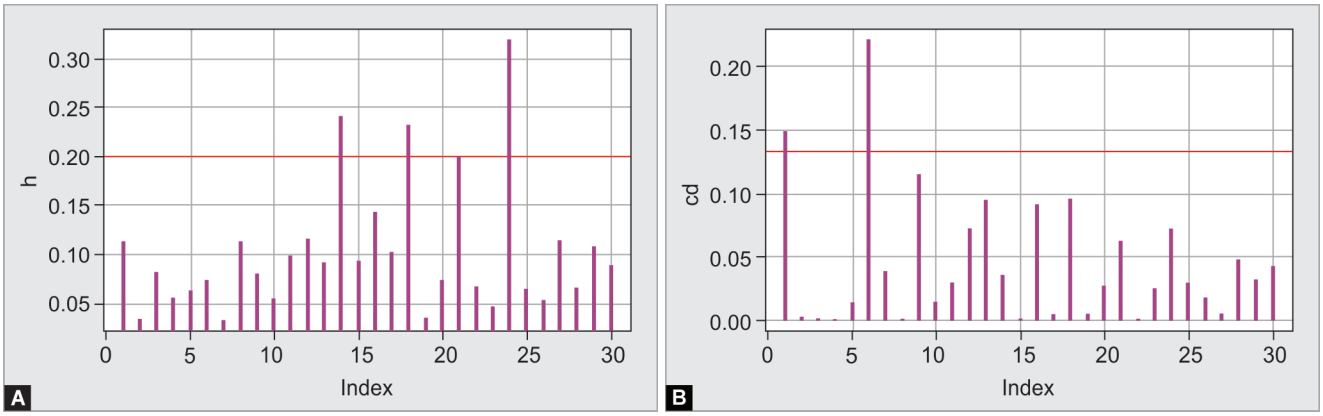



**Fig. 2:** Normal Q-Q plot of the standardized residuals to check for violations of assumptions of normality




**Figs 3A and B:** Residual plot to detect outliers and influential observations

observations for accuracy and validity. Observations that have Cook's distance greater than 4/*n* can be described as outliers. 4/30 = 0.13333. There is one observation (observation number 6) that has Cook's distance greater than 0.13333. These observations warrant further investigation (Appendix).

Multicollinearity can be detected using a correlation matrix before fitting the regression model.[10] If two independent variables to be included in the model have a statistically significant linear correlation, they are likely to cause multicollinearity problems. A variance inflation factor (VIF) is also used to detect multicollinearity.[11] VIF allows a quick measure of how much a variable contributes to the standard error in the fitted regression model. For the variables involved, the VIF will be very large, when there are significant multicollinearity issues. A VIF of over 10 is indicative of a multicollinearity problem. As seen from Table 2, $X_1 \ldots X_6$ have a VIF less than 10. Hence, there is no evidence of multicollinearity.

Constant variance assumption violation can be checked using Breusch–Pagan test.[12] There is homoscedasticity, as *p*-value = 0.1143 > 0.05, and so the null hypothesis can be rejected: $H_0 = \text{var}(x_1) = \text{var}(x_2) = \text{var}(x_3) = \text{var}(x_4) = \text{var}(x_5) = \text{var}(x_6)$. Therefore, there are no violations of the multiple linear regression model assumptions. We start by fitting the full model (using all six explanatory variables):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_6 x_6 +$$

Depending on ANOVA (Table 3), with such a large test statistic ($F$ = 10.50) and small *p*-value (0.0000124< 0.001), we reject the null hypothesis that all six population slopes are zero ($H_0$: $X_1 = \ldots = X_6 = 0$), in favor of the alternative hypothesis that at least one of these slopes does not equal zero. This indicates that the model is useful in predicting supervisor ratings.

**Table 2:** No evidence of multicollinearity as variance inflation factor is <10

| | *Variance inflation factor* |
|---|---|
| $X_1$ | 2.667060<5 |
| $X_2$ | 1.600891<5 |
| $X_3$ | 2.271043<5 |
| $X_4$ | 3.078226<5 |
| $X_5$ | 1.228109<5 |
| $X_6$ | 1.951591<5 |

**Table 3:** Analysis of variance (ANOVA)

| *Source* | *Degrees of freedom* | *Sum of squares* | *Mean of squares* | *F value* | *p value* |
|---|---|---|---|---|---|
| Model | 6 | 3147.96634 | 524.66106 | 10.50 | 0.0000124 |
| Error | 23 | 1149.00032 | 49.95654 | | |
| Total | 29 | 4296.96667 | | | |

From the summary of the coefficients (Table 4), it is seen that only the regression coefficient of $X_1$ is significantly different from zero. Variable selection for regression analysis can be done in a number of ways. One of the most famous ways is doing it stepwise.[13] Then, the suggested model becomes

$$y = \beta_0 + \beta_1 x_1 + \beta_3 x_3$$

By fitting the suggested model (Table 5), we will get

$$y = 9.8709 + 0.6435 x_1 + 0.2112 x_2$$

By comparing the two models (the full model and the suggested model

| *Model* | *Full model* | *Suggested model* |
|---|---|---|
| Adjusted R square | 0.6628 | 0.6864 |
| AIC | 210.4998 | 205.1387 |

**Table 4:** Summary of coefficients

| | *Estimate* | *Std. error* | *t value* | *Pr(>\|t\|)* |
|---|---|---|---|---|
| Intercept | 10.78708 | 11.58926 | 0.931 | 0.361634 |
| $X_1$ | 0.61319 | 0.16098 | 3.809 | 0.000903* |
| $X_2$ | 0.07305 | 0.13572 | −0.538 | 0.595594 |
| $X_3$ | 0.32033 | 0.16852 | 1.901 | 0.069925 |
| $X_4$ | 0.08173 | 0.22148 | 0.369 | 0.715480 |
| $X_5$ | 0.03838 | 0.14700 | 0.261 | 0.796334 |
| $X_6$ | −0.21706 | 0.17821 | −1.218 | 0.235577 |

**Table 5:** Suggested model of variable selection for regression analysis

| | *Estimate* | *Std. error* | *t value* | *Pr(>\|t\|)* |
|---|---|---|---|---|
| Intercept | 9.8709 | 7.0612 | 1.398 | 0.174 |
| $X_1$ | 0.6435 | 0.1185 | 5.432 | 9.57e−06* |
| $X_3$ | 0.2112 | 0.1344 | 1.571 | 0.128 |

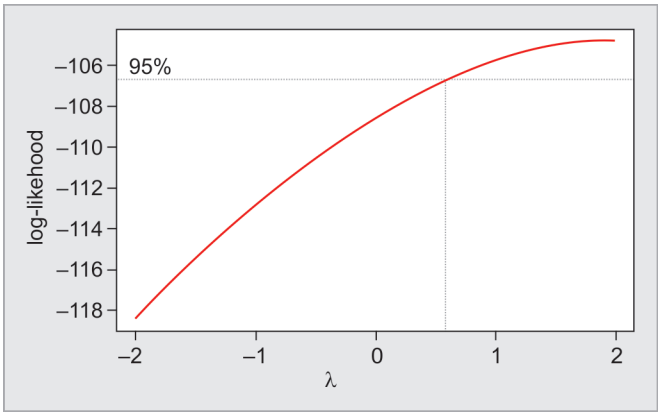



**Fig. 4:** Box–Cox transformation plot

Also, as *p*-value <0.05 in the ANOVA test, we can conclude that the full model is significantly different from the suggested model and that the suggested model is better. By using the Box–Cox transformation[14] plotto ensure the usual assumption for linear model hold, $\lambda$ is almost 1, so we do not need any kind of transformation (Fig. 4).

## Discussion

In this study, we used regression analysis to determine the relationship between supervisor characteristics and overall satisfaction with supervisors as perceived by the employees of dental departments in hospitals in Saudi Arabia. We conducted a survey that included aquestion designed to measure the overall performance of a supervisor (response *Y*), as well as six questions (explanatory variable) that were related to specific activities involving interactions between supervisors and employees.[15] There were two broad types of variables included in the study. Variables $X_1$ (handles employee complaints), $X_2$ (does not allow for special treatment), and $X_5$ (too critical of poor performance) relate to direct interpersonal relationships between the employee and the supervisor, whereas variables $X_3$ (opportunity to learn new things) and $X_4$ (raises based on performance) are of a less personal nature and relate to the job as a whole. Variable $X_6$ (rate of advancing to better jobs)serves more as a general measure of how the employee perceives their own progress in the hospital and is not a direct evaluation of the supervisor.

We have observed that only $X_1$ (handles employee complaints) and $X_3$ (opportunity to learn new things) have an impact on the response *Y* (overall rating of job being done by the supervisor). There is a strong positive relationship between $X_1$ (handles employee complaints)and *Y*(overall rating of job being done by the supervisor).There is also a positive relationship between $X_3$ (opportunity to learn new things) and *Y* (overall rating of job being done by the supervisor). Therefore, when the supervisor listens to employees and handles their complaints, and gives them the opportunity to learn new things, the supervisor becomes favorable.

The model to predict the overall rating job done by a supervisor depending on $X_1$ (handles employee complaints) and $X_3$ (opportunity to learn new things) is:

$$y = 9.8709 + 0.6435x_1 + 0.2112x_2$$

We conclude that subjective evaluations and objective performance are closely related and that the firm is at least partially informed about the differences in productivity across supervisors. Our paper thus complements Lazear, Shaw, and Stanton in finding large productivity differences across supervisors in a very different setting than the simple service-sector jobs they had considered.[6] We go beyond their analysis and provide an approach for understanding variation in supervisor behavior in a more typical setting where objective performance metrics are difficult to obtain, and firms instead rely on subjective ratings. Our analysis sheds light on the supervisor's role in the widespread and growing use of subjective rating systems.

However, on a set of objective criteria, we also observe that teams managed by lower raters tend to be outperformed by those managed by higher raters. This outcome can only be accounted for in our model by differences in managerial ability to elicit output. Two further findings corroborate this interpretation. First, we find that higher raters tend to earn more themselves, suggesting they are more valued by the firm. Second, subordinates working for higher raters tend to receive a pay that is more closely aligned to their performance, as implied by our model if the heterogeneity in ratings across supervisors stems from their ability to impact the marginal cost of effort. Finally, from self-reports, we also know that workers matched to higher raters are more satisfied with their immediate supervisors, and we find they are less likely to quit or change supervisors.[4] This suggests workers benefit from being matched to a high rater, even though they also exert more effort.

Overall, our research demonstrates that rater heterogeneity is an important aspect of employment relationship at a firm and has a significant impact on the careers and outcomes of employees and supervisors, as well as for the firm itself.[3] Differential leniency bias cannot be simply used to interpret rater heterogeneity. Instead, it is an important part of the differential ability to manage and elicit efforts from subordinates.[4] On a practical level, this suggests caution in addressing rater heterogeneity using practices such as forced scales or disincentivizing deviations from rating norms. Such practices might well interfere with the ability of supervisors to effectively manage their teams.[4]

### Limitations

In this study, to be able to conduct the multiple regression analysis, we transformed the ordered response (ordinal data) to numerical data. However, with the transformation, we may lose the characteristic behavior of the ordinary response. In the future, one may use ordinal logistic regression to deal directly with the nature of response without any transformation.

## Conclusion

There is a strong positive relationship between handling employee complaints and the overall rating of the job being done by the supervisor. There is also a positive relationship between an employee's opportunity to learn new things and the overall rating of the job being done by the supervisor. Therefore, when the supervisor listens to employees and handles their complaints, and gives them the opportunity to learn new things, the supervisor becomes favorable.

## Clinical Significance

We provide an approach for understanding the variation in supervisor behavior in a more typical clinical setting where objective performance metrics are difficult to obtain, and

organizations instead rely on subjective ratings. An understanding of the relationship between supervisor characteristics and overall satisfaction with supervisors as perceived by the employees of dental departments in hospitals is valuable to improve employee–supervisor relations, which can improve the overall functioning.

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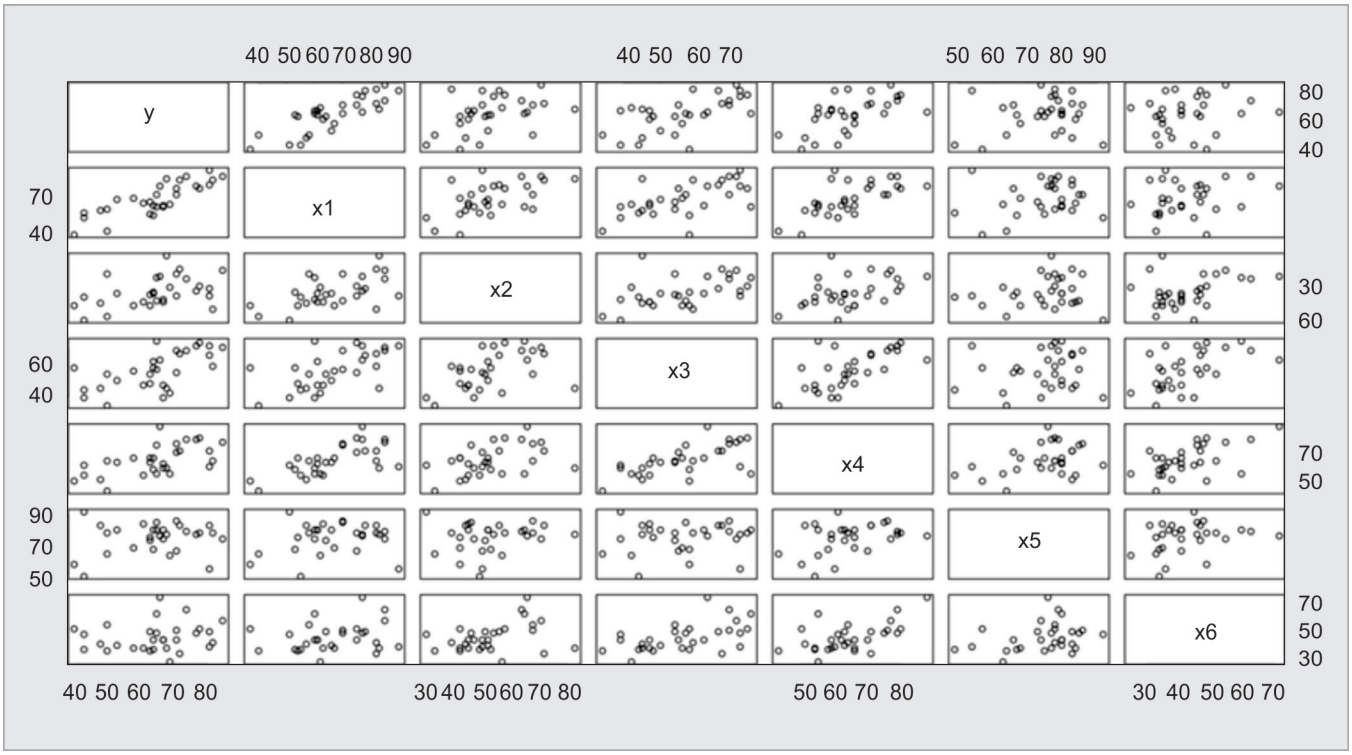


**Appendix:** Plot for the whole data