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# Cost Models For ISO 9000

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Predictive models were developed to estimate the effort required for domestic construction contractors to achieve ISO 9000 registration. The best predictor was the number of employees in the registered unit. A major cost factor is the presence of procedure writers within the company.

**Key Words:** ISO 9000, Cost Models, Survey, Documentation, Construction

## Objectives

The objective of this paper is to define useful cost models for domestic construction contractors seeking ISO 9000 registration. No predictive cost models have been published in this area. Recognition of the need for documented quality management systems in the construction industry is growing. Competition and customer pressure are given as reasons for seeking registration under ISO 9000 (Lew, 1994). The number of ISO 9000 registered firms in the US and Europe continues to grow. US construction companies are seeking registration primarily under ISO 9001 and 9002. The extensive documentation and auditing requirements of ISO 9000 registration require a significant commitment of time and resources (Bray 1996). This study uses statistical methods to develop predictive models for time and costs associated with ISO 9000 registration.

## Need for Research

The most important barriers to achieving ISO 9000 registration are believed to be development of documentation, procedures and work instructions (ISO 9000 1993). Registration barriers may affect the cost and effort required for ISO 9000 registration and may also affect potential cost savings from ISO 9000 registration.

Construction contractors will be most interested in the amount of effort required to achieve ISO registration. Effort may be measured in time and cost. Time required for registration is of interest because a contractor will want to estimate the amount of resources that will have to be committed to the registration effort.

## Method

*Model Development*

Registration costs include startup costs and annual maintenance costs. Startup costs include internal and external costs. Internal startup costs include planning, procedure writing and documentation, internal audits and training. External startup costs include registrar and consultant fees. Annual costs have similar internal and external components. ISO 9000 is documentation-intensive. The time required for registration is believed to be greatly influenced by the number and complexity of procedures that must be documented. Registration costs are directly related to registration time requirements.

A single variable to measure and describe the complexity of documentation has not been identified. Instead, the level of documentation effort was estimated indirectly using other simply measured variables. Number of employees and annual sales were used as a gross estimator of documentation effort. Both number of employees and annual sales give an approximation of the overall size of the firms' operations. Number of employees and annual sales are only rough estimators of documentation effort. However, the variables are easily measured and compared.

Most contractors would choose between ISO 9001 registration and ISO 9002 registration. The model includes an indicator variable for the registration pursued to determine if 9001 registrations require more effort than 9002 registrations.

Registration effort may be related to the current stage of development of the firm's quality culture. A previous study indicated that companies with a functional quality management system achieved registration with less effort than companies without functional quality management systems (ISO 9000 1993). However, no statistical evidence has been presented to show that simply having a quality management system reduces the effort required for registration. A better indicator of a firm's readiness to pursue registration may be the presence of an experienced procedure writer at the management level. Indicator variables for the presence of a quality management system and a procedure-writer were included in the model to determine the effect on registration effort.

A model for cost savings may be proposed. Cost savings may come from increased market share and productivity improvement. Companies without quality management systems may have greater potential savings than firms that have previously implemented quality systems and already captured a share of potential savings due to productivity improvements. Total savings should be in proportion to the overall size of the company. Firms with functional quality systems or experienced procedure-writers may be more effective in designing ISO 9000 quality programs that result in cost savings. Based on the previous discussion, the same indicator and quantitative variables proposed for estimating registration effort may be used for the cost savings model. In order to achieve a better understanding of factors affecting ISO registration, the following linear models with covariates and interaction effects were proposed:

$$C = ß_0 + ß_1 Z_{i1} + ß_2 Z_{i2} + ß_3 Z_{i3} + ß_4 X_{i1} + ß_5 X_{i2} + ß_6 Z_{i1} X_{i1} + ß_7 Z_{i1} X_{i2} + ß_8 Z_{i2} X_{i1} + ß_9 Z_{i2} X_{i2}$$

$$ß_{10}Z_{i3}X_{i1} + ß_{11}Z_{i3}X_{i2} + ß_{12}X_{i1}X_{i2}$$
$$ß_{13}Z_{i1}Z_{i2} + ß_{14}Z_{i1}Z_{i3} + ß_{15}Z_{i2}Z_{i3} + ?$$

$$S = a_0 + a_1Z_{i1} + a_2Z_{i2} + a_3Z_{i3} + a_4X_{i1} + a_5X_{i2}$$
$$a_6Z_{i1}X_{i1} + a_7Z_{i1}X_{i2} + a_8Z_{i2}X_{i1} + a_9Z_{i2}X_{i2}$$
$$a_{10}Z_{i3}X_{i1} + a_{11}Z_{i3}X_{i2} + a_{12}X_{i1}X_{i2}$$
$$a_{13}Z_{i1}Z_{i2} + a_{14}Z_{i1}Z_{i3} + a_{15}Z_{i2}Z_{i3} + ?$$

$$T = d_0 + d_1Z_{i1} + d_2Z_{i2} + d_3Z_{i3} + d_4X_{i1} + d_5X_{i2}$$
$$d_6Z_{i1}X_{i1} + d_7Z_{i1}X_{i2} + d_8Z_{i2}X_{i1} + d_9Z_{i2}X_{i2}$$
$$d_{10}Z_{i3}X_{i1} + d_{11}Z_{i3}X_{i2} + d_{12}X_{i1}X_{i2}$$
$$d_{13}Z_{i1}Z_{i2} + d_{14}Z_{i1}Z_{i3} + d_{15}Z_{i2}Z_{i3} + ?$$

$$A = \mu_0 + \mu_1Z_{i1} + \mu_2Z_{i2} + \mu_3Z_{i3} + \mu_4X_{i1} + \mu_5X_{i2}$$
$$\mu_6Z_{i1}X_{i1} + \mu_7Z_{i1}X_{i2} + \mu_8Z_{i2}X_{i1} + \mu_9Z_{i2}X_{i2}$$
$$\mu_{10}Z_{i3}X_{i1} + \mu_{11}Z_{i3}X_{i2} + \mu_{12}X_{i1}X_{i2}$$
$$\mu_{13}Z_{i1}Z_{i2} + \mu_{14}Z_{i1}Z_{i3} + \mu_{15}Z_{i2}Z_{i3} + ?$$

Where:

C = Startup costs of registration, $.
S = Annual cost savings after registration, $.
T = Time required to achieve registration, MH.
A = Annual costs to maintain ISO registration, $.
$Z_{i1}$ = 0 if firm "i" had functional quality system present prior to ISO registration; 1 if else
$Z_{i2}$ = 0 if prior to ISO registration, firm "i" had manager with chief responsibility for developing procedures; 1 if else
$Z_{i3}$ = 0 if firm "i" had ISO 9001 registration; 1 if ISO 9002 registration.
$X_{i1}$ = Annual sales for registered site "I," $1000.
$X_{i2}$ = Number of employees under site "i" management.
$ß_j$ = Regression coefficients in startup costs model.
$a_j$ = Regression coefficients in savings model.
$d_j$ = Regression coefficient in time model.
$\mu_j$ = Regression coefficient in annual costs model.
? = Error term in models.

## *Hypothesis*

Tests of significance were conducted at the 0.95 confidence level to test the hypothesis:

$$H_0: \text{ All } ß_j = \text{All } a_j = \text{All } \mu_j = \text{All } d_j = 0$$

After testing the full models, analysis was performed to identify useful and statistically significant models by removing variables that did not significantly contribute to the prediction of the response variables.

### *Sampling Procedure*

Since ISO 9000 is new to the US construction industry, no data could be obtained from US construction companies. Instead, a sample was drawn from US companies with characteristics believed to be common to domestic construction firms.

A sample of registered firms was obtained from the CEEM ISO 9000 Registered Company Directory, May 1994 Update ("ISO 9000 Registered" 1994). The firms were selected on the basis of the registration scope published in the Registered Company Directory. The chief characteristic of the firms selected for the survey was the production of a custom product in a batch of one. Only firms currently registered under ISO 9001 or ISO 9002 were considered. Companies with registration scopes indicating the primary concern of the quality system was maintaining operation of a continuous assembly or process flow line were not considered. No specific instrument for selection was used. The researcher simply read the registration scope and determined if the selection criteria were met.

The selection criteria were somewhat subjective. An alternative approach would be using cost data from foreign construction companies. Data from foreign construction companies were not used due to difficulties in obtaining the data and difficulty in comparing cost data for construction companies operating in other cultures. Fundamental differences in the economic systems of other countries complicate use of data from foreign companies.

No effort was made to compare the companies sampled to "typical" construction companies or to establish operational characteristics of a "typical" construction company. The only common characteristic was production of custom products and the absence of an "assembly-line" style production process.

### *Telephone Survey*

The questionnaire shown in Table 1 was developed to collect data for the proposed models. The questionnaire was administered by telephone interviews with each firm's quality manager. Steps were taken to achieve a high response rate. Two weeks prior to the telephone survey an explanatory letter and a copy of the questionnaire was sent to the quality manager in charge of ISO 9000 at each firm. Two weeks after telephone interviews were begun, a second notice was sent to firms the researcher had been unable to contact. Response rates of 70 percent to 90 percent may be expected in surveys of elite professional groups (Dillman 1978).

Each questionnaire required 20 to 30 minutes to administer by telephone. An open-ended discussion format was used. The researcher asked questions about the firm's quality management system. Functional quality management systems were those that the interviewee indicated had authority from management to carry out the company's quality policies. The number of employees and the presence of a procedure-writer are fairly objective questions.

Problems arose in estimating annual sales for registered firms that did not record annual sales. For example, the production unit of a large firm may operate nearly independently of the balance of the company. The estimated production or total value of contracts was used in place of annual

sales. The number of employees in the registered production unit was used rather than the total number of employees for the company.

Table 1

*Survey Form*

1. Prior to seeking iso registration, how many employees worked at this site?
2. Before seeking iso registration, did this site have a functioning quality program such as tqm, mbnqa, deming or others (name_____)? Yes / No
3. Prior to seeking registration, did this site include a person whose chief responsibility was writing procedures, work instructions or specifications, or managing those activities? Yes / No
4. What was the approximate annual sales (or production) in $ of this site before seeking iso registration? If there are multiple sites, estimate the share that can be credited to this site.
5. Estimate the total employee-hours that were required to obtain the initial iso registration of this site. Do not include time required to maintain registration.
6. What was the approximate total of all costs in $ for the initial registration of this site, including the initial registrar charges? Do not include ongoing or annual costs. If there are multiple sites, estimate the cost that can be assigned to this site.
7. What are the estimated total annual costs in $ at this site to support continuing iso registration? This would include annual registrar charges, personnel, indirect costs and any other costs associated with maintaining registration at this site.
8. What are the estimated total annual savings in $ at this site that can be attributed to obtaining iso registration? This should include new sales or production that occur due to registration. Do not deduct the costs of maintaining registration from this figure. If there are multiple sites, estimate the savings that can be assigned to this site.

Cost figures were verified during the telephone interview in order to insure that registrar and personnel costs had been included. Other costs included consultants and training. When records were not available, employee-hours were estimated by the quality manager with the help of the researcher. The reported data represent the best estimate of the firm's quality manager. In most cases the quality manager had maintained accurate cost records.

Estimating cost savings was much more difficult. Few firms had attempted to measure cost savings. The accuracy of the estimated savings data is low.

## Results

### *Survey Demographics*

A full data abstract is not included in this report. However; some interesting observations from the summary statistics are listed.

1. The overall useful response rate was 81 percent. Of 98 sites selected, 79 participated in the survey. Even after repeated attempts, five were never contacted. Only four refused to participate after being contacted. The high response rate means the data are not likely to be affected by response bias.
2. The survey included 43 percent ISO 9002 registered firms and 57 percent ISO 9001 registered firms.
3. The average startup costs for all firms was $ 191,480 ($Z_1 = 0$ or 1, $Z_2 = 0$ or 1).

4. For firms without a procedure-writer prior to registration ($Z_2 = 1$), the average startup cost was $214,976.
5. For firms with a procedure-writer ($Z_2 = 0$), the average startup cost was $146,296.
6. For firms without a procedure-writer or a functional quality management system prior to registration ($Z_1 = Z_2 = 1$), the average startup costs was $155,538.
7. For firms with a procedure-writer or a quality management system ($Z_1 = Z_2 = 0$), the average startup cost was $140,948.
8. Average startup cost for ISO 9001 firms was $266,479 ($Z_3 = 0$).
9. For ISO 9001 firms with neither a quality management system nor a procedure-writer prior to registration, average startup costs were $202,767 ($Z_3 = 0$, $Z_1 = Z_2 = 1$). For ISO 9002 firms the corresponding cost was $91,136 ($Z_3 = Z_1 = Z_2 = 1$).
10. The median startup costs for ISO 9001 without a procedure-writer or a quality management system in place prior to registration ($Z_3 = 0$, $Z_1 = Z_2 = 1$) was$100,000.

*Confidentiality of Data*

All graphs in this study are shown with dimensionless axes. The data are plotted to show the goodness of fit, but the scale is omitted to protect the confidentiality of survey respondents.

*Test of Models*

The models represented by equations I - 4 were tested. Ho was rejected at the 5 percent level for equations 1, 3, and 4. The annual savings model represented by equation 2 was not significant at the 5 percent level.

More statistically significant and useful models were created by elimination of variables from the full models. No significant model for annual savings was found. The reduced models shown have a maximum probability that no regression coefficients are zero (maximum F value), and no individual coefficients exceed 0.05 likelihood of being zero. In all cases the adjusted R2 shown are only slightly below the maximum value obtained from the best combination of variables. For all models presented here, validity was confirmed with plots of standardized residuals and normal probability plots.

*Startup Cost Reduced Model*

The best-cost model was found to be:

$$C = 110{,}880 + 321 Z_2 X_2 \quad (5)$$

Where $Z_2 = 0$ if firm has a procedure-writer or 1
if else
$X_2$ = number of employees
$R^2 = 63.7\%$

Equation 5 maybe reduced to two linear equations.

If $Z_2 = 0$ (had a procedure-writer):

$$C = 110{,}880 \quad (6)$$

If $Z_2 = 1$ (no procedure-writer):

$$C = 110{,}880 + 321 X_2 \quad (7)$$

The fitted equations are shown in Figure 1.

*Time to Registration Reduced Model*

The best time for the model was found to be:

$$T = 4722 + 3.65\ Z_2\ X_2 \quad (8)$$

$R^2 = 26.1\%$

Equation 8 may also be reduced to two linear equations.

If $Z_2 = 0$ (had a procedure-writer):

$$T = 4722 \quad (9)$$

If $Z_2 = 1$ (no procedure-writer):

$$T = 4722 + 3.65\ X_2 \quad (10)$$

The fitted equations are shown in Figure 2

*Annual Cost Reduced Model*

The best annual cost model was found to be:

$$A = 32{,}643 - 30{,}822\ Z_3 + 138\ Z_2\ X_2 \quad (11)$$

$R^2 = 85.6\%$

Equation 5 maybe reduced to four linear equations.

If $Z_2 = Z_3 = 0$(Had procedure-writer and ISO 9001 registration):

$$A = 32{,}643 \quad (12)$$

If $Z_2 = 1$, $Z_3 = 0$(No procedure-writer, had ISO 9001 registration):

$$A = 32{,}463 + 138\ X_2 \quad (13)$$

If $Z_2 = 0$, $Z_3 = 1$ (Had procedure-writer, had ISO 9002 registration):

$$A = 1821 \quad (14)$$

If $Z_2 = Z_3 = 1$ (No procedure-writer, had ISO 9002 registration):

$$A = 1821 + 138\ X_2 \quad (15)$$

The fitted equations are shown on figure 3.

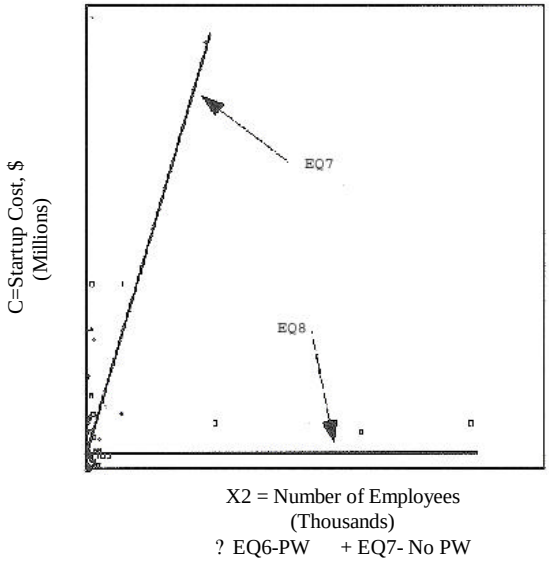


*Figure 1:* Fit of startup costs.

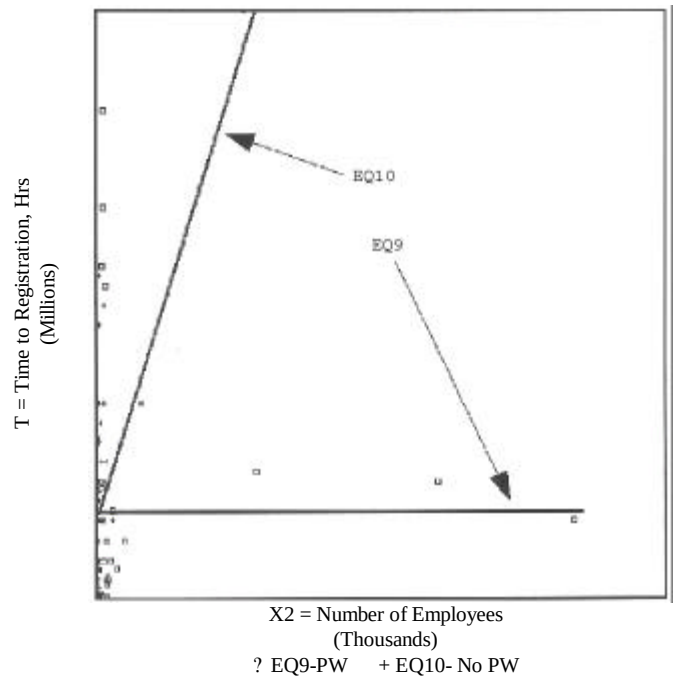


*Figure 2:* Fit of time to registration.

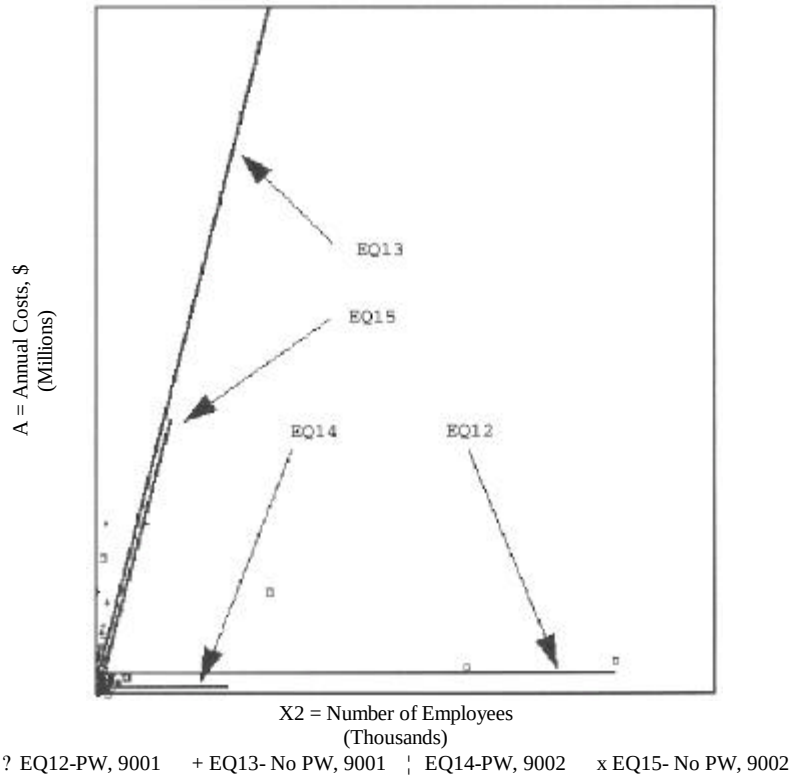


*Figure 3:* . Fit to Annual Costs.

## Conclusions

### *General Observations*

Experience in writing procedures is an important factor in startup costs, time required for registration and annual costs of registration. The effect of procedure writing was the single most important factor in all models.

The costs and efforts required for ISO registration are more directly related to the number of employees managed than the size of the firm as reflected by annual sales.

The effort required in time and startup costs are not significantly different for ISO 9001 and ISO 9002. However; ISO 9001 has significantly higher annual costs.

Having a functional quality system in place prior to registration did not significantly lower the costs and efforts of obtaining ISO registration. One reason could be the lack of agreement over what constitutes a functional quality system. In some firms the quality system consists of detecting and correcting defects prior to shipment. This is more of an inspection approach. ISO 9000 requires setting up or modifying existing procedures to prevent problems, so it is not surprising that some firms with "quality management systems" are not efficient in obtaining ISO registration.

### *Implementation in Construction*

Construction companies pursuing ISO registration should concentrate on documentation and procedure writing. Cost savings does not seem to be a major reason for pursuing ISO 9000 registration. This does not mean that cost savings are not present. However, cost savings are difficult to measure. In addition, other factors such as market share play a larger role. A major obstacle for ISO 9000 registration in construction companies will be in creating and maintaining adequate procedures and documentation. Companies will need to take care to develop general procedures that may be customized for different projects. For example, the company may have a prefer-red method of constructing a manhole or a slab, but project specifications may require use of other methods. Companies will need to develop procedure-writing capabilities of construction personnel. One approach might be to build documentation gradually by targeting one or two activities on any project and absorbing documentation costs in the project overhead costs. A serious obstacle will be in keeping procedures current. ISO registration will likely cause increased use of planning at the foreman/superintendent level. The use of short look-ahead schedules made by field personnel will be helpful in ensuring that quality procedures are followed. The ISO quality system may require closer coordination between field and home office employees in the form of meetings and written records. Field personnel will have an increased paper work load from creating the records that show proper procedures were followed.

Employees that actually perform the work should be involved in writing procedures. If the employees cannot write the documentation, it is likely the process needs to be simplified or employees need additional training. Office personnel such as estimators usually have well-established procedures for taking-off jobs. The challenge will be to ensure that all personnel use

current procedures and to update procedures when required. The procedure-writing process will probably require both an experienced estimator and field supervisor. Specific procedures should have input from the personnel that will actually perform the work. The procedures that are developed should be documentation of the way the company's work is actually performed, rather than some ideal way of doing the work.

### *Additional Observations*

Several companies refused or were unable to respond to the survey. The parties contacted at two of the non-responding companies gave confusing reasons for not participating. One indicated that there was no one in the firm with overall responsibility for administrating the quality system. This seems unlikely. The other firm indicated that they could not provide the data requested because only the company's consultant had the information. This represents a fundamental lack of understanding of the commitment required to implement the ISO 9000 quality management system. One possible reason for pursuing registration with such an obvious lack of commitment would be in order to satisfy a customer's requirement for ISO registration for one or two projects. It is possible to achieve registration through the use of consultants without total commitment from top management. However, the registration would be extremely expensive to maintain. Companies should understand that ISO 9000 registration is meant to be a commitment from top management to a set of quality principles. Companies will not likely be able to afford the cost of ISO 9000 registration to bid on only a few projects.

A surprising result of the survey was the general lack of interest by ISO 9000 firms in the amount of savings achieved through ISO 9000. The majority of quality managers felt the savings were negligible. A majority of quality managers reported that top management gave strong support to the registration effort. These managers reported that they did not feel pressured to demonstrate cost savings from ISO 9000. This may indicate the development of a domestic "quality culture" where product quality is valued for reasons other than cost-cutting measures. It might have been expected that quality managers would go to great lengths to justify the expense of maintaining the quality system. However, that concern was not found in the study.

### *Interviewee Comments*

Several interviewees agreed to review and comment on the initial results of the study. Tom Polizzi, Quality Manager for Glenayre Electronics in Duluth, GA, stated that cost savings was not a major reason for Glenayre's decision to pursue registration. Major considerations were obtaining greater market share and increasing customer satisfaction. Polizzi suggests that since firms without procedure-writers seem to face higher costs and time requirements for registration, these firms are most likely to benefit from the use of consultants in procedure-writing (Polizzi 1994).

Raj Sikand, a consultant for Intertek Services in Fairfax, VA, provides consulting services for firms seeking registration. Intertek Services is an ISO 9002 registered consulting firm. Sikand confirms that others also see number of employees as an estimator of the effort required for registration. Intertek bases fees on the number of employees in the registration unit. The number of employees was a major estimator in the models of startup cost, annual cost and time required

for registration. Intertek's billing practice seems to confirm that number of employees is a reasonable estimator of effort required for registration (Sikand 1994).

Dick McDonnell, Production Manager for Digital Equipment Corp. in Sunnyvale, CA, agreed with the importance of procedure-writing. Digital had many repair processes to document and used a team approach to writing the actual repair procedures. McDonnell emphasized the requirement of continual commitment. One area of the site gets an internal audit each month, which helps maintain a state of constant readiness. In fact, the firm makes no special preparations for the regular registrar audits (McDonnell 1994).

### *Future Research*

The annual savings model was not statistically significant, due largely to a lack of agreement on how savings should be calculated. Development of more accurate methods for estimating savings and cost is a potential area for future research.

A more sophisticated instrument for selecting companies could be developed. This would help focus the results of future work. Additional work in developing cost models should include methods for capturing costs of creating and maintaining the quality system. Future research in this area would probably need to focus on a small number of companies and attempt to fully understand the relationships between the various costs and components in the quality system. Additional research on procedure writing may be valuable since procedure writing was such a significant factor in the study. An effective method of classifying procedures and documentation or predicting the effort required to produce procedures and documentation would be useful.

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