Creating a Framework for Predicting Craft Worker Turnover Utilizing the Corporate Human Resource Database

by

Richard D. Bruce, PhD. and
Richard J. Gebken, PhD.
Technology & Construction Mgt
Missouri State University
Springfield, Missouri 65897, USA
richardbruce@missouristate.edu
richardgebken@missouristate.edu

David W. McCandless, EdD.
School of Technology
University of Central Missouri
Warrensburg, Missouri 64093, USA
dmccandless@ucmo.edu

Abstract: *This study used multiple regression analysis to examine the craft worker database of a $50 million Missouri construction company to identify a quantifiable relationship between the independent variables of hire age, craft, and role in order to predict the dependent variable of time with the company. The database was analyzed using the regression function and stepwise selection approach in Statistical Package for the Social Sciences (SPSS) version 13. The results indicated that when craft was taken out of the equation, the independent variables of role and age at hire were significant predictors of an employee's length of employment at the construction company.*

Keywords- Construction, Predicting Turnover

I. Introduction

As with many service industries, the construction industry relies heavily on its first line workers. Retention of these employees is an industrial and technical problem faced by all construction companies. Because every company is different in what it can offer these employees in regards to benefits, working environment, expected duties, and pay, there can be no universal formula for employee retention. Instead, each company must understand its workforce well enough to direct change. Such an understanding comes in part from the collection of key data. If construction companies were able to predict the likelihood of success for an employee at their company based on the characteristics of known variables, they may be able to avoid the high turnover employee and retain the at-risk employee.

Need for the Study

This study examined the employee database of one Missouri construction company to identify a quantifiable relationship between the independent variables of hire age, craft, and role in order to predict the dependent variable of time with the company. If a regression model could be generated, the company would be able to identify and possibly retain at-risk employees. They may even be able to identify and change the working condition causing the loss of multiple employees with similar characteristics. Other companies could also use the methodology to study their own workforce to identify similar relationships and build their own predictive model.

Research Question and Hypotheses

This study set out to answer the following research question: Are the independent variables of craft, role, and hire age significant predictors of an employee's length of employment? This question is answered in this study by building a multiple regression model and analyzing its multiple R and R^2. The null hypothesis (H_O) is that the population value for multiple R is not significantly different from zero (R=0). In other words, the regression model should not be used to predict the amount of time an employee will stay with the company because the ratio of the predicted value to the observed value, which is the correlation coefficient (R), is not significantly different from zero. As the difference between the two values decreases, the ratio (R) would be closer to one showing that a relationship does exist. This leads to the second hypothesis. The alternate hypothesis is that the population value for multiple R is significantly different from zero ($R \neq 0$) meaning that the model works for predicting the employee's length of employment.

Assumptions, limitations, and delimitations

The first assumption made in this study that was presumed but not verified is the data included all concrete/carpenters and ironworkers that were hired and left the company from 1997-2005. Because the database was acquired from the human resource person that had been with the company for the entire duration, it was assumed the database was accurate. The second assumption was that employees labeled as concrete/carpenters were hired as such and remained concrete/carpenters for the full duration of their employment. The third assumption was that the sample population is an accurate representation of all employees hired since the company began in 1985 (before the database was created).

One of the limitations of this study was that the researcher accepted that the prediction model would not be affected by the dichotomous variables of craft and role based on the robustness of multiple regression analysis. Further studies on construction employee retention should seek out ways to make the variables interval or ratio.

In regard to delimitations, it should be noted that the sample size was limited to those employees that were hired and left the company in the period from 1997-2005. Thus, even though there were several employees that were hired prior to 1997 but left before 2005, they were not included in the sample. Similarly, the sample does not include

employees that were hired during the 1997-2005 period and were still with the company at the time of the study.

II. Literature Review

There are two main sections in this literature review. The first section, underlying theories, presents the psychological and predictive frameworks associated with turnover. The second section, turnover studies, reviews the current supply of available studies in other disciplines and in the construction industry.

Underlying Theories: Psychological Frameworks

Motivation

The two authors that appear in the literature discussing motivation are Maslow and Herzberg. According to Maslo [1], the desire to self-actualize one's true potential explains much of man's motivation to work. A carpenter might aspire to be a master carpenter or a construction manager. This desire might lead him or her to take several different jobs in hopes of fulfilling that desire. Herzberg [2] presented two motives for work including a need to evade pain and a need to grow psychologically. In a previous study [3], the authors interviewed workers about a specific time they felt good about their jobs and a specific time they felt bad about their jobs. Through a series of probing follow-up questions, the authors were able to establish common satisfiers and dissatisfiers. The researchers renamed their positive satisfiers as motivators and their negative dissatisfiers as hygiene factors. The theory then became Herzberg's Motivation-Hygiene theory.

Civil engineering professors Rathavoot Ruthankoon & Stephen Ogunlana [4] used Hersberg's theory and published results that applied to the construction industry. The authors asked 64 engineers and 61 foremen from 29 different construction sites to explain the circumstances of a situation that brought them great satisfaction or unpleasant circumstances at their job. The authors identified 345 critical events which were translated into Herzberg's 14 categories, with 4 additional categories. Some motivation factors included responsibility and possibility of advancement whereas hygiene factors included working conditions and site safety. They found that many factors led to both satisfaction and dissatisfaction, thus suggesting that Herzberg's theory was not applicable. While interpersonal relationships lead to both results, the authors suggested that project managers try to create strong relationships, assist others in talking through conflicts, and foster an environment of teamwork to help increase job satisfaction.

Job Satisfaction

Several studies have been done to establish variables attributing to job satisfaction. In Job Attitudes: Review of Research and Opinion [5], authors Herzberg, Mausner, Peterson, and Capwell provide several commonly researched factors of dissatisfied workers including age, length of service, sex, education, personality, income, position, marital

status, number of dependents, work history, and social class to name a few. As part of their literature review, the authors present several studies that attempt to make connections between the variables in a variety of fields. Some of the problems noted by the authors in comparing the various studies include varying questions and varying level of quality in research design. In addition, Borcherding & Oglesby [6] were able to identify several job satisfiers in the field of construction by asking foremen and superintendents open-ended questions. The challenge of their job, support from their superiors, and good crews were some of the satisfiers among the sample.

Underlying Theories: Predictive Frameworks

The literature presents several studies that set out to predict employee behavior based on independent variables. Many of these studies use Karl Pearson's product moment coefficient of correlation. Pearson's r is superior to covariance because it provides an interpretable magnitude of relationship from zero to plus or minus one while factoring out the variables' scales [7]. The value of r at +1 is just as strong as -1, in fact; a 1 represents a perfect linear relationship between two variables. Multiple R is a ratio between the predicted value of the dependent variable and the actual value of the dependent variable.

Common Elements of Turnover Studies

Most of the turnover studies, like the Herzberg related studies, incorporate the use of a survey instrument to collect job satisfaction, interest, and biographical data. Other instruments elicit the respondents' intelligence, aptitude, and personality type [8] in order to predict the likelihood of turnover. These studies require further research beyond just studying existing data.

The researcher did find one study that focused on readily available employee records to predict the probability of turnover. In his dissertation titled *The Prediction of Voluntary Employee Turnover for a Commercial Bank*, Michael Grubbs [9] analyzed the employee database of one Mississippi bank to answer the research question of whether variables contained in regularly collected employee files could be used to predict turnover. The data included 467 employees in the period 1980-1985. Of the 467 employees, the researchers classified 213 as stayers because they remained with the company through 1985 and classified 254 as leavers because they left sometime during the period.

Whether the employee was a stayer or leaver was the dependent variable. The independent variables included age, sex, education level, race, rate of promotion, tenure, past employment, time with previous employer, number of promotions, pay increases, local level of unemployment, local level of retail sales activity, and ending pay. All of these variables were included in other studies found in the literature, however, local level of unemployment and local level of retail sales activities were new. Grubbs ultimately found that age, sex, tenure, past employment, ending pay, number of promotions, and local level of retail sales activity were significant (.05 alpha) predictor variables.

Turnover Studies in Construction

The researcher found one dissertation that specifically addressed predicting turnover in the field of construction. In The Migration of Boom Town Construction Workers: Wanderlust or Adaptation, sociology major Virginia Fahys-Smith [10] presented results of a 122 question survey she administered to 1432 inhabitants of 9 western Boom Towns. The purpose of her research was to test her hypothesis that work stability is a greater predictor of migration than wanderlust.

The researcher grouped her sixteen independent variables in three main categories: costs for remaining in a boomtown, individual characteristics, and variables testing transiency. The variables in each category can be seen in Table 1. Fahys-Smith [10] utilized Pearson's product moment correlation to determine the strength of the relationship between the preceding sixteen independent variables and the dependent variable plans for migration. Because she used a survey rather than a database, the dependent variable was the respondents' plans for migration rather than their actual migration. The researcher did not perform a follow-up study to determine whether the employee's plans for migration resulted in actual migration. The following table shows the strength of the correlation between the listed independent variable and the dependent variable.

Table 1

Relationships between independent variables and plans for

Costs For Remaining in a Boom Town		Simple R
1.	Boom Town conditions	.17
2.	Dissatisfaction with facilities and services	.28
3.	Job security	-.37
4.	Status incongruence	.16
5.	Family absent	.04
6.	Commuting time	.17
7.	Lack of housing integration	-.34
Individual Characteristics		
8.	Occupation	.32
9.	Age	-.36
10.	Education	.18
11.	Income	.18
12.	Marital status	.02
13.	Family size	-.07
14.	Upward mobility	-.20
Variables Testing Transiency		
15.	Wanderlust	-.005
16.	Past mobility	-.06

The lower predictors included marital status, family size, and past mobility. Another non-significant predictor was family absent. The researcher hypothesized that being away from one's family for long periods would drive a worker to plan for an alternate job where they could be around their family, but this was not supported by the research. Finally, just as the author had hypothesized, wanderlust was not a significant predictor of transiency.

Applying the Results

All of the dissertations and journal articles presented above provide rationales and needs for their studies often quoting the cost of turnover and the benefits of retention. Few, however, provide practical methods for solving the problem with high turnover once the researcher identifies the significant independent variables.

Abraham [8] suggests that companies, upon learning that relationships exist between independent and dependent variables, create a weighed application blank. The interviewer would then be able to identify a possible length of stay based on the prospective employee's past proliferation for job-hopping or some other variable. This is not a new concept. Fifteen years earlier, England [11] suggested that companies use weighted application blanks in the same fashion.

III. Methodology

The population is composed of all concrete/carpenter and ironworker employees working for this particular construction company. *Concrete/Carpenters* represented employees that built forms, pour, finish concrete, and performed other operations necessary but did not build with steel. *Ironworkers* represented employees that built with steel. That is, they erected and welded the steel frame and envelope of a building. *Management* included all foremen, lead men, and superintendents that were responsible for the work of others whether they were concrete/carpenters or ironworkers. *Non-management*, on the other hand, included all crewmembers that were not responsible for the work of others.

The sample in this research included the 375 employees that were hired since 1997, but left the company before 2005. The data was collected from the company's database during summer of 2005. Because all of the cases that were hired in that period were included in the study and no selection was required, selection bias was not an issue in this study. Furthermore, because the researchers did not stand to benefit from the results in any way there were no threats to internal validity.

For this study, there are three continuous, independent variables: craft, role, and hire age. These variables were chosen because the researchers wanted to stick to data that would be readily available in an employee database. Satisfaction surveys take a great deal of time and money to develop. If companies were able to quickly analyze the relationship of variables that currently exist in their employee databases, they would be more apt to run the analyses.

The three variable coding schemes follow. First, there were two craft categories: concrete/carpenters and ironworkers. Concrete/carpenters were coded as 0 and ironworkers were coded as 1 in regard to craft. Second, there were two role categories: non-managerial (crewmembers) and managerial (foreman, lineman, and superintendent). Non-managerial workers were coded as 0 and managerial workers were coded as 1 in regard to role. Third, the continuous variable hire age was used as the independent variable. According to Hayden [12], "using dichotomous data in regression does not violate the continuous assumption as long as the data are inherently continuous" (p. 23). Therefore, while it appears that an employee is either a concrete/carpenter or an ironworker and a crewmember or a manager, the researcher theoretically assumed that the variables represent continuous scales. Thus, instead of zero representing a concrete/carpenter worker, it is going to represent a zero amount of ironworker. Similarly, instead of zero representing a crewmember, it is going to represent a zero amount of management.

The dependent variable will be time at the company (days here). This is determined by subtracting the hire date from the exit date. Days were used as the appropriate level of detail due to the large number of employees that worked less than one month and one year. While there are still two employees that worked less than a day, it is quite a bit less than those that worked less than one year. In fact, of the 375 employees, 13.9% worked less than one month and 70% worked less than a year.

Type I Error

If this study determines a correlation between hire age, role, and craft (independent variables) and time with the company (dependent variable), the company could use the information to improve the work situations of at-risk employees they would like to retain. Similarly, if the study shows that 18-year-old ironworkers are likely to quit after just 2 years of service in a non-managerial role, then the company may decide to target those employees to improve their work situations. The company may be able to retain those employees.

This is a positive consequence if the model is in fact correct and multiple R does not equal zero. That is, if we reject the null hypothesis that R=0, we are accepting that there is a linear relationship. The company could then make changes to their hiring and promotion strategies knowing that their changes would have an effect on employee retention.

If, however, the company retains a false null hypothesis it would be committing a Type II error and the damages could be great. The company could lose thousands of dollars in doing nothing. They would not see that a relationship truly does exist between these variables and miss the opportunity to retain at-risk employees. Employees would continue to leave the company after two years without a promotion to management thus costing the organization the benefits of internal promotions.

Another possible area for error is if the company rejects the null hypothesis even though it is actually true (Type I error). In other words, the company could obtain significant results showing that there is a relation between the time here and hire age, role, and craft (R≠0) when there actually is not a relationship (R=0). In this case, the employer would lose thousands of dollars investing in employees that had no intentions of leaving.

While the initial costs to proactively retain employees would be greater than doing nothing, there are still benefits to committing a Type I error. For instance, if the company rejects the null hypothesis and starts valuing their believed to be at-risk employees, the ripple effect could be higher employee morale. This is an unknown as it is a future possible return on investment. In reality, committing a Type I error means that the company will have to spend money to retain employees that were never at risk. Therefore, if the company were worried about initial costs, they would not want to lower alpha because it would increase the likelihood of having to spend unnecessary money.

It is in this sense that the .05 alpha was chosen. If the alpha is lowered to .01, the probability of committing a Type II error increases.

Statistical Technique

Since the researchers wished to predict the values of a dependent variable based on two or more independent variables, a multiple linear regression analysis was performed. The stepwise approach was chosen due to the ability of the SPSS software to enter variables based on the probability of their F statistic. A probability of .05 or less was required for entry of the variable into the model and .10 or greater for removal from the model. Once a regression model was created, *R* Square (R^2), was used to measure the effectiveness of the model since R^2 represents "the proportion of variability in the dependent variable that is attributable to the regression equation" (p.247) [13, p. 247].

IV. Results

The data did not meet all required multiple regression assumptions (e.g., Hayden, 2006 [13]). First, because the sample included all cases recorded from 1997 to 2005 it is not a random sample of the entire population (all employees working for the company past and present). Second, age at hire is the only variable with normally distributed data. Craft, role, and time here did not have normal distributions. This is evident in Table 2 where the only mean close to the median for the same variable is age at hire. All of the other variables have quite different means and medians indicating they are not normal. Third, role is the only independent variable that had a linear relationship with the dependent variable days here. This can be seen in Table 3.

Table 2

Descriptive Statistics of Variables

	Craft (0=conc/carp, 1=iron)	Role (0=not mgt, 1=mgt)	Days here	Age at hire
N	375.000	375.000	375.000	375.000
Mean	.340	.110	350.430	29.200
Median	.000	.000	170.00	27.000
Std. Deviation	.474	.316	455.268	9.326
Skewness	.685	2.471	2.184	.874
Std. Error of Skewness	.126	.126	.126	.126
Kurtosis	-1.540	4.125	5.118	.118
Std. Error of Kurtosis	.251	.251	.251	.251

Table 3

Correlations of Variables

		Craft	Role	Days Here	Age at Hire
Craft	Pearson Correlation	1.000	-0.075	-0.067	-0.043
	Sig. (2-tailed)		0.145	0.200	0.411
	N	375.000	375.000	370.000	375.000
Role	Pearson Correlation	-0.075	1.000	0.380(**)	0.187(**)
	Sig. (2-tailed)	0.145		0.000	0.000
	N	375.000	375.000	370.000	375.000
Days Here	Pearson Correlation	-0.067	0.380(**)	1.000	-0.032
	Sig. (2-tailed)	0.200	0.000		0.535
	N	370.000	370.000	370.000	370.000
Age at Hire	Pearson Correlation	-0.043	0.187(**)	-0.032	1.000
	Sig. (2-tailed)	0.411	0.000	0.535	
	N	375.000	375.000	370.000	375.000

****. Correlation is significant at the 0.01 level (2-tailed).**

Once the descriptive statistics were analyzed, the stepwise linear regression analysis was performed. Only two of the three independent variables met the criteria for selection based on the probability of F (<=.05 to enter, >=.10 to remove). Table 4 shows that when craft was in the model, it adversely affected the other variables. From the Regression Model Summary as shown in Table 5, we see that in model 1 only 18% of the variability in the employee's time with the company (days here) can be explained by the variable role. This figure increases to 19.2% when age at hire is added to the model.

Table 4

Excluded Variables

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Craft (0=conc/carp, 1=iron)	0.013[a]	0.272	0.786	0.014	0.994
	Age at Hire	-0.110[a]	-2.314	0.021	-0.119	0.965
2	Craft (0=conc/carp, 1=iron)	0.010[b]	0.207	0.836	0.011	0.993

a. Predictors in the Model: (Constant), Role (0=not mgt, 1=mgt)

b. Predictors in the Model: (Constant), Role (0=not mgt, 1=mgt), Age at Hire

c. Dependent Variable: days here

Table 5

Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.424[a]	0.180	0.178	412.785
2	0.438[b]	0.192	0.187	410.397

a. Predictors: (Constant), Role (0=not mgt, 1=mgt)

b. Predictors: (Constant), Role (0=not mgt, 1=mgt), Age at Hire

c. Dependent Variable: days here

The Overall F Test, as shown in Table 6, is used to test the null hypothesis that R=0. According to Norusis [13], this table shows how much variability the regression model explains and how much the residuals explain (not explained by the model). The table also shows the probability of acquiring your measured R value (or larger) when the "true population value is 0" (p. 249). The Overall F Test shows a significance value less than .0005. This means that it is highly unlikely that one will obtain an R value of .438 or larger when the true population value is zero. In multiple regressions, the overall test is "important only if it is not significant" (p. 249). Because the significance level for the Overall F Test is less than .0005, one must reject the null hypothesis that R=0. As Norusis [13] points out, the Overall F Test here is not important because it shows that the null hypothesis must be rejected. The researchers here must therefore go on to examine the hypothesis concerning the individual regression coefficients of the variables rather than focusing on the model.

Table 6

Overall F Test

Model		Sum of Squares	df	Mean Square	F	Sig
1	Regression	13962649	1	13962648.530	81.945	.000[a]
	Residual	63555951	373	170391.290		
	Total	77518600	374			
2	Regression	14864165	2	7432082.380	44.127	.000[b]
	Residual	62654435	372	168425.901		
	Total	77518600	374			

a. Predictors in the Model: (Constant), Role (0=not mgt, 1=mgt)

b. Predictors in the Model: (Constant), Role (0=not mgt, 1=mgt), Age at Hire

c. Dependent Variable: days here

Table 7 illustrates that the un-standardized coefficients for role and hire age in model 2 were 641.403 and -5.359 respectively. The t statistics (with significance levels in parentheses) for these two variables were 9.377 (.000) and -2.314 (.021) respectively.

Again, both variables have significant t values or they would not have been chosen by the stepwise method.

Table 7

Regression Coefficients Model

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	**Std. Error**	**Beta**	**t**	**Sig**
1	(Constant)	281.901	22.620		12.462	0.000
	Role (0=not mgt, 1=mgt)	611.861	67.592	0.424	9.052	0.000
2	(Constant)	435.071	69.921		6.222	0.000
	Role (0=not mgt, 1=mgt)	641.403	68.403	0.445	9.377	0.000
	Age at Hire	-5.359	2.316	-0.110	-2.314	0.021

a. Dependent Variable: days here

The linear equation for model 1 would be:

$$\hat{Y} = 281.90 + 611.86(X_1)$$

The linear equation for model 2 would be:

$$\hat{Y} = 435.071 + 641.403(X_1) - 5.359(X_2)$$

Where: $\hat{Y}$ = the predicted days with the company

X_1 = the role of the employee

X_2 = the age at hire of the employee

In examining the model's residuals, the difference between the expected days here and the observed days here, the histogram shows a normal distribution and the P-P Plot shows a linear relationship.

V. Discussion

Because both models 1 and 2 showed that a significant linear equation existed between the independent variables and the dependent variable, the null hypothesis (R=0) must be rejected. This decision was based on the un-standardized coefficient t –test significance levels (role and age at hire) being in the rejection zone of the two-tailed test of significance. The t statistics for these two variables were .000 and .021 respectively. However, the results were based on models excluding the craft variable. If one were to exclude craft, the new question would be; Are the independent variables of role and hire age statistically significant predictors of an employee's length of employment at this construction company? The answer would be, yes, these two variables are significant predictors of an employee's time with this company.

In regards to the usefulness of the findings, the information could be used to study the phenomena concerning the employees with the longest length of employment. The company could analyze such questions as how soon these employees were promoted, how often they received pay increases, and so forth. Therefore, it has practical value with this company. If another construction company collects similar data on their employees and follow the same procedures, they may find that these variables are not significant predictors of time with the company. However, they will certainly better understand the variables associated with their workforce. Another benefit of the study concerns other similar construction companies. Since this company represents a typical general contractor model in which the company self-performs concrete and steel, many other general contractors could use the methodology to examine their own employee databases.

In order to help the employer understand their database further, a canonical correlation technique could be used. The researcher could include several other bits of information including experience before hire, on the job training, and employee satisfaction ratings. This information could be used to predict not only days with the company, but an employee's potential for promotion to management. Employers not currently recording this information may decide to start collecting the data so they may be able to perform similar studies.

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Biography

RICHARD BRUCE received his PhD. in Technology Management from Indiana State University in 2008. He was on the faculty at University of Central Missouri (2002-2008) as a tenure-track assistant professor. In 2008, he joined the faculty at Missouri State University. He has been an active member, coordinator, and recently elected director of the Associated Schools of Construction region IV.

RICHARD GEBKEN received his PhD. in Civil Engineering from the University of Texas at Austin in 2006. He joined the faculty at Missouri State University in 2006. He has been an active member and is now the coordinator for the Associated Schools of Construction region IV.

DAVID MCCANDLESS received his EdD. in Educational Leadership from the University of Missouri in 2008. He owned a residential building and roofing construction company since 1985 and joined the faculty at the University of Central Missouri in 2004. He is now a tenured associate professor at UCM where he is also the program coordinator for the construction management program.