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A STOCHASTIC MODEL OF PROFESSIONAL ACCOUNTANT TURNOVER*

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Abstract

High turnover rates have tended to characterize the public accounting profession. Probabilistic estimates that generate duration models have been often used in engineering and to a lesser extent in business fields. This study suggests a stochastic model and methodology to be used in professional accountants' turnover analysis. The model is simple, can help evaluate numerous policy implications and allows for future turnover prediction. A set of published data is utilized to illustrate the use of the model. This illustration describes turnover patterns for accounting staff broken down by admission year and sex. The stochastic model also predicts the number of accountants that will quit in 5 yr.

High personnel turnover has tended to characterize public accounting firms; however, published data do not convey information which may be useful for turnover policy decisions. For example, Montagna (1974) states that "the average turnover in a big eight firm is about 20% of the nonpartner professionals per year. The mode is at 20%, with the range extending from 15 to about 45%" (p. 51). Murdock (1979) states that "at the manager level which is just before entry to partnership, we had 24% turnover this past year, 15% the year before, and 11% the year before that" (p. 15). These statistics do not reveal the reasons for high turnover rates in the past and typically can not accurately predict professional accountants' turnover in the future.

Several studies have been performed to identify the reasons of high turnover rates in the public accounting firms. Rhode *et al.* (1976) collected biographical, personality and vocational information up to several years prior to the subjects' graduation. The subjects then were classified into the turnover group (that left public accounting) and a nonturnover group (that stayed in public accounting until five years after the collection of the above mentioned information). The results showed some significant biographical, personality and vocational differences between the two groups. However, these tests might not used by a firm to screen and select potential employees. Rhode *et al.* (1976) reported that the questionnaires "were given to

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the students within a research setting. They were told the data would only be used for research purposes. If they thought the test results would be used for selection purposes, perhaps, they would have answered differently and have eliminated some of the differences that were found" (p. 798).

Ferris (1981), on the contrary, found that personal factors, such as age, marital status, education and social background, did not influence professional accountants' organizational commitment; however, work-related characteristics did. Dillard & Ferris (1979) found that turnover decisions resulted from "the receipts of negatively-valued outcomes and the perception that these outcomes can be avoided in alternative positions" (p. 185).

Rhode *et al.* (1977) also used an exit interview approach. They sent a 39-item questionnaire to 99 subjects who terminated within the first 3½ yr of public accounting employment. Results suggested that improvement over the work and supervisory relationships and communication should be made. However, there is a problem of the validity of subjects responses. Rhode *et al.* (1977) stated that "employees who are let go by their firms may be simply rationalizing their dismissal by blaming the firm for poor job support. There is no way to determine from our data if this is true (or false)" (p. 174).

Knapp (1980) identified numerous factors that affected turnover decisions. The most important factors are: favorable employment alternatives, long overtime hours, and management's indifference to employees. Pearson (1977) also listed eight management dysfunctional behavioral patterns that encouraged professional accountants' turnover.

The abovementioned studies seem to suggest that the unfavorable or perceived unfavorable work environment encourages professional accountants' turnover. Some remedies were also suggested by those studies. For example, Dillard & Ferris (1979) suggested the change of perceptions of task instrumentality and of the actual occurrence of certain task outcomes. The adaptation of changes, i.e. response to uncertainty, is also important since (1) the level of perceived uncertainty and the level of job satisfaction are negatively correlated (Ferris, 1977), and (2) the level of organizational coping and employee performance are positively correlated (Ferris, 1982).

Although survey studies identify the reasons for high turnover rates, they seem to offer limited help to the quantitative analysis of professional accountants' turnover data. This study describes a stochastic model for personnel turnover analysis. Only actual turnover data are required by the model. Therefore the problem of survey subjectivity is avoided. The model's description is followed by a discussion of its policy implications. A small set of published data is then utilized to demonstrate the potential usefulness of the model. Finally, some conclusions are given.

MODEL DESCRIPTION

This stochastic model is based on the engineering reliability theory and statistical inference. It has been used to study war, strike and job duration (see Morrison & Schmittlein, 1980; Schmittlein & Morrison, 1983, for details). Let the random variable T denote the time to quitting of a person and $f(t)$ denote the probability density function (pdf) of T. The probability of quitting as a function of time can be defined by

$$P(T \leqq t) = \int_0^t f(x)\mathrm{d}x = F(t) = 1 - R(t), t \geqq 0 \quad (1)$$

where $F(t)$ is the cumulative distribution function (CDF) which shows the probability that the person will quit by time t; $R(t)$ is the reliability function which shows the probability that the person will not quit by time t.

The quitting rate (defined by reliability theory as "failure rate") during any time interval $[t_1, t_2]$ can be defined as

$$FR(t_1, t_2) = \left[\frac{R(t_1) - R(t_2)}{R(t_1)}\right]\left(\frac{1}{t_2 - t_1}\right), \quad t_2 > t_1 \geqq 0. \quad (2)$$

The quitting rate at any point of time is defined as the limit of the "failure rate" as the length of the interval $[t_1, t_2]$ approaches zero

$$q(t) = \lim_{\Delta t \to 0} \frac{R(t) - R(t + \Delta t)}{\Delta t R(t)}$$

$$= \frac{f(t)}{1 - F(t)}, \qquad t \geqq 0. \tag{3}$$

The quitting rate described by (3) is an individual quitting rate. On the individual level, the pdf of T can be assumed as a Weibull function that allows for time-dependent quitting (Morrison & Schmittlein, 1980)

$$f(t) = (\lambda\beta)t^{\beta-1}e^{\lambda t^{\beta}}, \quad t \geqq 0, \lambda > 0, \beta > 0 \tag{4}$$

where λ is a scale parameter, and β is a shape parameter.

The Weibull function is selected for its richness in specifying the pdf of T. It is meaningless to determine the value of $f(t)$ at any point of time since, by definition, $f(t)$ should be zero at any point of time. However, $f(t)$ increases, does not change, or decreases when t increases if $\beta < 1$, $\beta = 1$, or $\beta > 1$, respectively. It is useful for deriving the individual quitting rate that increases, does not change, or decreases over time. The CDF of T and the individual quitting rate are

$$F(t) = 1 - e^{\lambda t^{\beta}}, \qquad t \geqq 0 \tag{5}$$

$$q(t) = 1 - \lambda\beta t^{\beta-1}, \qquad t \geqq 0. \tag{6}$$

There are four interesting characteristics of the individual quitting rate. First, it is also a Weibull distribution. Second, if $\beta = 1$ then the quitting rate is a constant. Third, if $\beta < 1$ then the quitting rate decreases over time, i.e. the longer the individual has stayed on his job, the less likely for him to quit. Fourth, if $\beta > 1$ then the quitting rate increases over time, i.e. the longer the individual has stayed on his job, the more likely for him to quit. In other words, β is a simple but useful indicator of an individual's quitting behavior.

In addition to the individual quitting rate, a population quitting rate, $\bar{q}(t)$, is also of interest and can be useful for policy decisions. In order to determine the population quitting rate, an integration over all individuals has to be done. Theoretically, λ and β can vary across the population, and the population quitting rate can be represented by a bivariate mixing distribution. However, this becomes "mathematically burdensome and overly complicated" (Morrison and Schmittlein, 1980, p. 232). Therefore, it is assumed that β is fixed and λ has a gamma distribution with parameters α and r (Morrison & Schmittlein, 1980)

$$g(\lambda) = \frac{\alpha}{\Gamma(r)}(\alpha\lambda)^{r-1}e^{-\alpha\lambda}, \quad \alpha > 0, r > 0. \tag{7}$$

The gamma distribution is selected because in general it can handle the heterogeneity of the individual quitting rates.[1] The pdf, CDF, and $\bar{q}(t)$ are

$$h(t) = \frac{r\beta\alpha^{r}t^{\beta-1}}{(\alpha + t^{\beta})^{r+1}}, \qquad t \geqq 0 \tag{8}$$

$$H(t) = 1 - \frac{\alpha^{r}}{(\alpha + t^{\beta})^{r}}, \qquad t \geqq 0 \tag{9}$$

$$\bar{q}(t) = \frac{r\beta t^{\beta-1}}{\alpha + t^{\beta}}, \qquad t \geqq 0. \tag{10}$$

There are two interesting characteristics of the population quitting rate. First, if $\beta < 1$ then $\bar{q}(t)$ decreases monotonically over time. Second, if $\beta > 1$ then $\bar{q}(t)$ starts at zero, then monotonically increases to point $t^{*} = [\alpha(\beta-1)]^{1/\beta}$, and then monotonically decreases to zero, i.e. even if the individual quitting rate increases over time, the population quitting rate will eventually decrease.

[1] Morrison & Schmittlein (1980) stated that "If we allow the scale parameter λ to vary, we allow for differing mean durations. Clearly this form of heterogeneity is mandatory. However, if we fix β we are not being all that restrictive" (p. 232).

POLICY IMPLICATIONS

Based on the stochastic model described in the last section, numerous analyses with important policy implications can be performed. First, a comparision of the population quitting rates and βs between different firms in the same time period can be made.[2] If, for example, firm A and firm B have the same mean population quitting rate (such as the rate reported in Montagna [1974]), but the β of firm A is greater than that of firm B, then the auditors in firm A are less likely to stay in their jobs. The policy implication for firm A is that it has to be more aggressive in its effort to provide a better work environment for its employees than firm B to retain its employees.

Comparisons of the population quitting rates and βs within a firm can also be performed by contrasting, for example, (1) male with female accountants, (2) staff with senior accountants, (3) audit staff with tax staff, and (4) MBA and undergraduate degree accountants, given that the individuals in a specific group were hired in the same year. The results of comparisons will indicate which group is more likely to quit. If the two group population quitting rates are significantly different, then the firm might not have provided an equally good work environment for the high turnover group. If the mean population quitting rates are not significantly different, but one group has a higher β, then the high β group is more likely to quit. The comparisons will also indicate the problems of the firm's past recruiting policies, i.e. whether in a particular year the firm has recruited a group of employees with unusually high turnover rates. They will also provide some indications to whether the firm has to change its existing policies to reduce further turnover of the existing work force, i.e. whether to provide a better work environment to a particular group of employees in the firm or somehow change the perception about the work environment of a particular group of employees. The possible changes are mentioned in Dillard & Ferris (1979) and Pearson (1979).

The turning point of a firm's (or of a particular group's) population quitting rate (t^*) can also be determined if $\beta > 1$. The turning point will show to the firm when the population quitting rate of the firm (or of a particular group) starts to decrease. This result can aid the firm's future recruiting and planning.

The final analysis is the prediction of turnovers in the future. α, β and r can be estimated therefore $h(t)$, $H(t)$ and $\bar{q}(t)$ can be determined. These parameters serve to forecast turnover.

AN ILLUSTRATION

This section utilizes a set of published data as a methodological model usage illustration and provides some tentative policy statements regarding the data. It should be noted at the outset that the sample size is small, and the data are secondary shown from a published source. However, for methodological illustration, the results are interesting.

Despite the richness and potential of this type of model, many empirical issues must be considered in its potential utilization. Among these we find: the validity of the adopted distributions, their representational robustness, and their variability over time.

The next section draws from a published study's data (Konstans & Ferris, 1981) to illustrate the feasibility of the proposed approach. The conclusions drawn are of illustrative nature as the data and nature of the data substantially limits its generalizability.

Data source

The data are adapted from Konstans & Ferris (1981) and presented in Table 1. (The original data are presented in terms of cumulative percentage of terminated employees. Therefore some transformations are in order.) The data

[2] The stochastic model is time dependent. Therefore comparisons are meaningful only if they are made for a prespecified time period.

TABLE 1. Number of quits*

Entry class				Number of quits									
				1 yr or less		1–2 yr		2–3yr		3–4 yr		4–5 yr	
Year	All	Male	Female	M	F	M	F	M	F	M	F	M	F
1974	130	101	29	2	0	18	8	20	10	20	3	8	2
1975	132	110	22	1	1	11	7	18	5	20	4		

*Adapted from Konstans & Ferris (1981).

report the number of staff accountants hired in 1974 and 1975 in one mid-western office of four different CPA firms as well as the number of those auditors terminated in the years 1974–1978. Termination is defined as leaving the firm, i.e. no distinction between quitting and firing is made.

Estimation procedure

Based on Table 1, six sets of quitting rates are calculated and reported in Table 2. The quitting rate is measured by dividing the number of professional accountants that quit in a year by its number at the beginning of the year. Table 2 and equation (10) provide the bases to estimate α, β and r.

There are several possible estimation procedures. A two-stage procedure is found the most time and cost efficient. The first stage is to regress $\log \bar{q}(t)$ on $\log t$. The difference between the regression coefficient of $\log t$ and 1 gives a reasonable estimate of β (see Appendix 1). The second stage is a hill-climbing numerical analysis procedure. It is a procedure such that a movement toward the final solutions proceeds through the alternative which offers the best improvement to the situation in one step (Winston, 1979). After a few steps, the values of α and r can be reasonably estimated.

Results

The results of estimations are presented in Tables 3 and 4. Table 3 shows the estimates of α, β, r and t^* for each of the two groups hired in 1974 and 1975 as well as for male, female and all accountants. Table 4 shows the results of goodness of fit tests for each of the six analyses.

Table 4 compares the observed number of quits with the estimated number of quits. A chi-square test is performed for each of the six analyses. Results indicate that the stochastic model fits well to all six cases, i.e. all the chi-squares are not significant. It should be noted that because of the small sample size, no alternative tests can be performed. If data for a longer (for example, 10 yr) time period was used, then

TABLE 2. Quitting rates

Year hired	t	All	Male	Female
1974	$t \leq 1$	0.0154	0.0198	0.0000
	$1 < t \leq 2$	0.2031	0.1818	0.2759
	$2 < t \leq 3$	0.2941	0.2469	0.4762
	$3 < t \leq 4$	0.3191	0.3279	0.2727
	$4 < t \leq 5$	0.2041	0.1951	0.2500
1975	$t \leq 1$	0.0152	0.0091	0.0455
	$1 < t \leq 2$	0.1385	0.1009	0.3333
	$2 < t \leq 3$	0.2054	0.1837	0.3571
	$3 < t \leq 4$	0.2697	0.2500	0.4444

TABLE 3. Parameter estimates

Year hired	Group	α	β	r	t*(yr)
1974	All	23.00	2.6838	0.895	3.91
	Male	15.30	2.5259	0.720	3.48
	Female	12.50	4.3358	0.360	2.36
1975	All	92.55	3.0055	1.365	5.59
	Male	137.50	3.4270	1.078	5.45
	Female	71.05	2.6364	3.903	6.07

TABLE 4. Goodness of fit tests

Year hired	t	All Observed	All Estimated	Male Observed	Male Estimated	Female Observed	Female Estimated
1974	$t \leqq 1$	2	4.86	2	4.50	0	0.79
	$1 < t \leqq 2$	26	20.87	18	16.25	8	7.69
	$2 < t \leqq 3$	30	28.56	20	19.97	10	8.02
	$3 < t \leqq 4$	25	23.90	20	16.24	3	4.31
	$4 < t \leqq 5$	10	16.33	8	11.43	2	2.37
	$t > 5$	39	35.48	33	32.60	6	5.81
Chi-square		5.8562*		3.4809†		1.7554†	
d.f.		2		2		2	
1975	$t \leqq 1$	2	1.92	1	0.86	1	1.17
	$1 < t \leqq 2$	18	12.25	11	7.72	7	4.98
	$2 < t \leqq 3$	23	24.93	18	19.46	5	6.79
	$3 < t \leqq 4$	24	28.76	20	24.99	4	5.03
	$t > 4$	65	64.14	60	56.98	5	4.04
Chi-square		3.6501*		2.6849†		1.7612†	
d.f.		1		1		1	

*Not significant at $\alpha = 0.05$.
†Not significant at $\alpha = 0.10$.

the data from the first half period (first 5 yr) could be used to generate estimates and then the data from the second half period (second 5 yr) can be used to test the robustness of the estimates. On the other hand if further cross-sectional data was available jack-knife techniques (Efron, 1979) could be used.

Table 3 illustrates five interesting facts that could be drawn from this type of analysis. First, all βs are greater than 1, i.e. the longer these accountants have stayed on their job, the more likely they will quit. Second, the β of the 1975 group is higher than that of the 1974 group, i.e. the former group is more likely to quit. Third, the β of the female accountants hired in 1974 is higher than that of their male counterparts, i.e. the female accountants hired in 1974 are less likely to stay. Fourth, the male accountants hired in 1975 are less likely to stay than their female counterparts. Finally, even though the quitting rates of the male and female accountants hired in 1975 are increasing (as shown in Table 2), they will be decreasing in 1980 and 1981 respectively. These types of observations could be useful for evaluating a firm's past recruiting policies and redesigning current work environment.

Table 5 presents the predicted number of quits in the years 1979–1982. The predictions

TABLE 5. Predicted number of quits

Year hired	Group	1979	1980	1981	1982
1974	Male	7.82	5.42	3.85	2.82
	Female	1.43	0.93	0.65	0.47
1975	Male	20.81	13.75	8.31	4.95
	Female	2.51	0.99	0.35	0.12
Subtotal	Male	28.63	19.17	12.16	7.77
	Female	3.94	1.92	1.00	0.59
Total	All	32.57	21.09	13.16	8.36

are separately made for male, female and 1974 group and 1975 group. According to this table, 33 staff accountants will quit in 1979. Twenty-nine of the 33 are male accountants. Eight of the 29 male accountants were hired in 1974. Based on predictions of this type, public accounting firms could better gauge levels of hiring, personnel policies and staff profile.

CONCLUSIONS

A gamma mixture of Weibulls model is used to theoretically describe professional accountants' quitting behavior. The use of the model is also empirically illustrated by a set of published data. The model's usage, as demonstrated, can serve to evaluate potentially important policy implications. It can provide insights on issues such as evaluation of past recruiting policies, and assessment and redesign of the current work environment. It is also useful for future planning and recruiting purposes since it can predict personnel turnover.

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APPENDIX 1

$$\text{Since } \bar{q}(t) = \frac{r\beta t^{\beta-1}}{\alpha + t^{\beta}} \tag{11}$$

$$\text{then } \log \bar{q}(t) = \log r + \log \beta - \log(\alpha + t^{\beta}) + (\beta - 1)\log t$$

$$= a_t + (\beta - 1)\log t \tag{12}$$

$$\text{where } a_t = \log \frac{r\beta}{\alpha + t^{\beta}} \tag{13}$$

therefore β can be estimated by the difference between the regression coefficient of $\log t$ and 1.

Based on (13)

$$\text{antilog } a_t = \frac{r\beta}{\alpha} - \frac{1}{\alpha}(\text{antilog } a_t)t^{\beta} \tag{14}$$

therefore theoretically α and r can be estimated by the intercept and regression coefficient of regressing antilog a_t on (antilog a_t)t^{β}. However, if the sample size is small, then the estimates are not accurate. In the study, a hill-climbing procedure is used to estimate α and r.