AFIT/GLM/LAL/99S-8

A METHODOLOGY FOR THE ANALYSIS AND PREDICTION OF AIR FORCE ENLISTED AIRCRAFT MAINTENANCE PERSONNEL RETENTION RATES USING ECONOMIC STATISTICS

THESIS

Peter D. Lommen, Captain, USAF

AFIT/GLM/LAL/99S-8

Approved for public release; distribution unlimited

DTIC QUALITY INSPECTED 4

19991026 038

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

AFIT/GLM/LAL/99S-8

A METHODOLOGY FOR THE ANALYSIS AND PREDICTION OF AIR FORCE ENLISTED AIRCRAFT MAINTENANCE PERSONNEL RETENTION RATES USING ECONOMIC STATISTICS

THESIS

Presented to the Faculty of the Graduate School of Logistics

and Acquisition Management of the Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

Peter D. Lommen, B.S.

Captain, USAF

September 1999

Approved for public release; distribution unlimited

Acknowledgements

I would like to thank Major Mark Ward, my advisor for this thesis, for leading me through this journey, and at times allowing me to drag myself through it. As his first thesis student, he was always ready to answer my questions. I would also like to thank my reader, Major Mike Rehg, who was behind the scenes making sure that I learned what I should from this work and also guiding Major Ward through his first "advisorship."

I would not have been able to complete this project, or the rest of the accompanying graduate school, without the encouragement, understanding and the unconditional love I received from my lovely wife Shannon. As always, she was here for me when I needed her, ready with a sympathetic ear, or encouraging word. And I want to thank my children, Reagan and Preston, who can now look forward to spending some time with Daddy. I love you all very much.

Pete Lommen

Table of Contents

List of Figures

List of Tables

Abstract

The purpose of this study is to investigate the effects of certain national economic indicators on enlisted aircraft maintenance personnel retention rates. To fulfill this purpose, this study builds a linear regression equation that can predict the retention rate using the civilian unemployment rate and the index of 11 leading economic indicators as the independent variables. Journal literature and economic texts were reviewed to identify the indicators as good predictors for changes in employee turnover.

The method of linear regression was used to build the model needed to predict the changes in the retention rate. The equation developed with this technique in the present research may help the Air Force Personnel Center predict future enlisted retention rate changes. AFPC's task of keeping a steady force has a central need of knowing the number of personnel that will be staying and leaving the force.

The results of this study show a strong relationship between the future retention rate of the enlisted aircraft maintenance force and the unemployment rate and the index of 11 leading indicators.

A METHODOLOGY FOR THE ANALYSIS AND PREDICTION OF AIR FORCE ENLISTED AIRCRAFT MAINTENANCE PERSONNEL RETENTION RATES USING ECONOMIC STATISTICS

I. Introduction

Background

Enlisted personnel retention in the United States Air Force has recently been identified as a major problem by Air Force Chief of Staff General Ryan in his *Special Interest NOTAM: Retention* dated 11 Dec 97. General Ryan states in this NOTAM that "one of the Air Force's major challenges today is to retain the high-quality people we need." The leadership of the Air Force has begun to explore why these airmen are leaving and what they can do to stop the exodus. To address this problem, Gen. Ryan focused on four areas: (1) Operations Tempo (OPTEMPO), (2) family care for deployed personnel, (3) quality of life, and (4) personnel programs.

The Air Force knows what it will take to accomplish the missions it is presented with in today's environment, what type and how much equipment and personnel are needed to ensure proper execution. Although the acquisition and retention of equipment can be effectively planned out years in advance, no explanation is available to effectively predict the retention of the personnel needs to accomplish the mission.

The Air Force personnel managers need to be able to effectively predict personnel fluctuations each year. This prediction would allow for greater accuracy in determining recruiting and retention goals. If a formula for determining the rate could be effectively found, then the personnel managers would be able to identify areas where bonuses should be used and the areas where recruiting should be increased. This effectiveness would increase the chances of having a stable force ready to meet the needs of the Air Force.

The need to better analyze and predict the future aircraft maintenance enlisted retention rates is the key area to be addressed in this thesis.

Problem statement

The objective of this thesis is to investigate the effects of certain national economic conditions and indicators on enlisted aircraft maintenance personnel retention rates.

Scope

The scope of this thesis will be to compare the retention rates of the aircraft maintenance AFSC's (2AXXX) to certain economic indicators. The researcher will refine the look at the AFSC's by looking at the retention rates of first and second term airmen (a "term" is a four year enlistment). This thesis will not be looking at career airmen (third term and beyond). Several complicating factors are introduced after a member has reached the 12 year point (third term airmen). Some of these factors are larger, older families, nearing larger promotions (from Non-Commissioned Officer to

Senior Non-Commissioned Officer), and the proximity of retirement (approximately 8 years away). For these reasons, the researcher will only be looking at airmen who have recently finished their first and second enlistments and are possibly more willing to leave the service to pursue a civilian career.

This thesis will also aggregate the data to exclude effects on specific population demographics in terms of gender, race, religion, and other demographic areas. The purpose of this research is not to decide if these economic indicators affect a certain type of enlisted maintainer, but whether the aggregated career field is affected by changes in the economy. The focus here is to predict if there will be enough trained personnel for the aircraft maintenance field, not if we have a "politically correct" mix of personnel to maintain the aircraft.

Outline of this thesis

This thesis is broken down into five areas, each taking a chapter to present and discuss the area. Chapter I is the introductory chapter. In Chapter II, a review of the literature will be presented to identify the specific problem and develop the hypothesis for this thesis. In Chapter III, the methodology to be used to test the hypothesis will be presented. In Chapter IV, the results of the test will be presented. The analysis of the results will also be included in chapter four. Finally, in Chapter V, the conclusions of the test and the recommendations for further research will be presented.

In Chapter I, the background of the problem has been presented. Also in chapter one, the problem statement for the thesis has also been stated. Finally, the scope of the study has been narrowed and an outline of the entire thesis has been presented.

In Chapter II, the journal literature concerning employee turnover is presented. First, an explanation of the different types of employee turnover is discussed. This further narrows and defines the scope of this thesis. Following this, a heuristic for the steps of employee turnover is presented. A study that tested these steps follows.

To begin to develop and test the hypothesis for this thesis, a presentation of the selection of the independent variables is included in Chapter II. First, a section to explain the independent variables necessary for this study is presented. Next is a description of the selection of these variables and how they are hypothesized to affect the dependent variable. Chapter II concludes with a summation of the journal literature and a summary and thesis hypothesis.

In Chapter III, the methodology for testing the hypothesis from Chapter II is presented. Statistical regression is used to test the hypothesis, so a study of statistical regression is necessary. The method of data analysis used in regression follows. As with any test, regression has pitfalls that are associated with it. These pitfalls are identified and discussed so that they can be applied to the actual model later in the thesis. Data collection is discussed next, including how the data was collected and manipulated so that it could be used in the regression. Finally, the hypothesis is translated into the specific statistical to be accomplished.

In Chapter IV the findings and analysis of the tests performed is presented. The models tested are presented, followed by a check of the usefulness of the models and then

a check of the estimation and prediction of the model. The pitfalls of regression are addressed, to ensure that they are accounted for in the equations set forth to test the models. Finally, an analysis of the models is performed to identify what the models are describing and what may be interpreted from them.

In Chapter V a summary of the entire work accomplished here is presented. Included in this summary, conclusions drawn from the study are presented. Then a list of recommendations, with possible future research topics, is identified. Finally, the thesis as a whole is summarized.

II. Literature Review

Introduction

This chapter will take a look at some of the journal literature available that deals with the research problem. First, an explanation and differentiation of employee turnover will be presented. Following that, three possible economic theories will be presented that have implications on this research. A summation of the two theories will then take the three theories and develop one hypothesis for this research. Finally, a discussion of the economic statistics to be used in the study will be presented.

Explanation of different types of turnover

To begin a study of retention, the present research must first identify what types of turnover to look for and why. To do this, this study must identify the types of turnover there are in the workplace. First of all, any time an employee leaves the job, he/she must be classified as either a voluntary or involuntary loss. Furthermore, the employee loss must be then identified as either an avoidable loss or an unavoidable loss. Finally, the employee's loss must be designated as a functional or dysfunctional loss. Once the turnover is identified and classified, this study's scope will be reduced to a specific type of turnover in hopes of finding the types of employees that will turnover given certain economic conditions.

In a study by Michael Ableson (1987), avoidable and unavoidable losses were studied. Avoidable losses are defined as losses of employees where the organization has

control over the employee leaving. This may be due to an involuntary loss (dismissal, layoff, or forced retirement) or voluntary movement of the employee (better pay, better working conditions, improved leadership/administration, or better organization found outside of the present organization). Unavoidable losses are defined as losses of employees where the organization has no control of the movement of the employee. Again, these types of losses can be either voluntary (move to new location for spouse, mid-career change, stay at home to take care of spouse/child, or pregnancy and no return) or involuntary (severe medical conditions or death). For this study, all losses that will be looked at will be assumed to be avoidable and voluntary. All involuntary losses will be removed from the data pool.

Ableson (1987) found that more avoidable losses of employees come from firms with A) high percentages of dual-career employees, B) a highly fluctuating economic environment or C) a "minimally educated staff" who may want to go back to school. To ensure that this study looks at avoidable losses, it is assumed that the enlisted aircraft maintenance personnel being looked at are "minimally educated staff," with a high school diploma and the technical training necessary to perform their jobs in the Air Force.

Employee turnover may also be classified as either functional or dysfunctional. A functional employee loss is one where the organization loses a low quality employee, one which is not highly valued. The loss of a poor quality employee is theorized to improve the organization. A dysfunctional loss is one where a high quality employee quits, the loss of an employee who is valuable to the organization. The loss of a high quality employee is thought to reduce the ability of the organization to do its job. In a study by

Dalton et al. (1981), 61.6% of all workers are high quality employees who are retained. Dysfunctional losses are 18.4% and functional losses are 13.3% (Dalton, 717). We can assume that we have removed all of the low-quality employees from the data. All functional losses are either administratively separated or are not eligible to reenlist due to lack of rank or lack of endorsement by their commander. Any of these situations lead to the assumption that these employees are not wanted or needed by the organization and should not be counted in the retention data.

Steps of employee turnover

Mobley (1977), identified a heuristic of the steps of employee turnover. He noted that previous research in the area of turnover concentrated on the correlation of job satisfaction and quitting one's job. He further stated that there was a consistent correlation between these variables that was not "especially high (usually less than .40)" (Mobley, 1977: 237). To try and find a set of variables that would have a higher correlation, Mobley (1977) ventured that "it is possible that other variables mediate the relationship between job satisfaction and the act of quitting" (Mobley, 1977: 237). To identify these possible variables, he presents possible intermediate steps between job satisfaction and the quit/stay decision.

Mobley (1977) presents his possible intermediate steps as a heuristic that is followed by an employee. In Figure 1, this heuristic is shown, with arrows drawn to explain the direction that an employee can take. In "normal" situations, an employee can

be expected to take all steps before making the "quit/stay" decision. An employee can also skip steps to get to the end (such as the impulsive "I quit" statement).

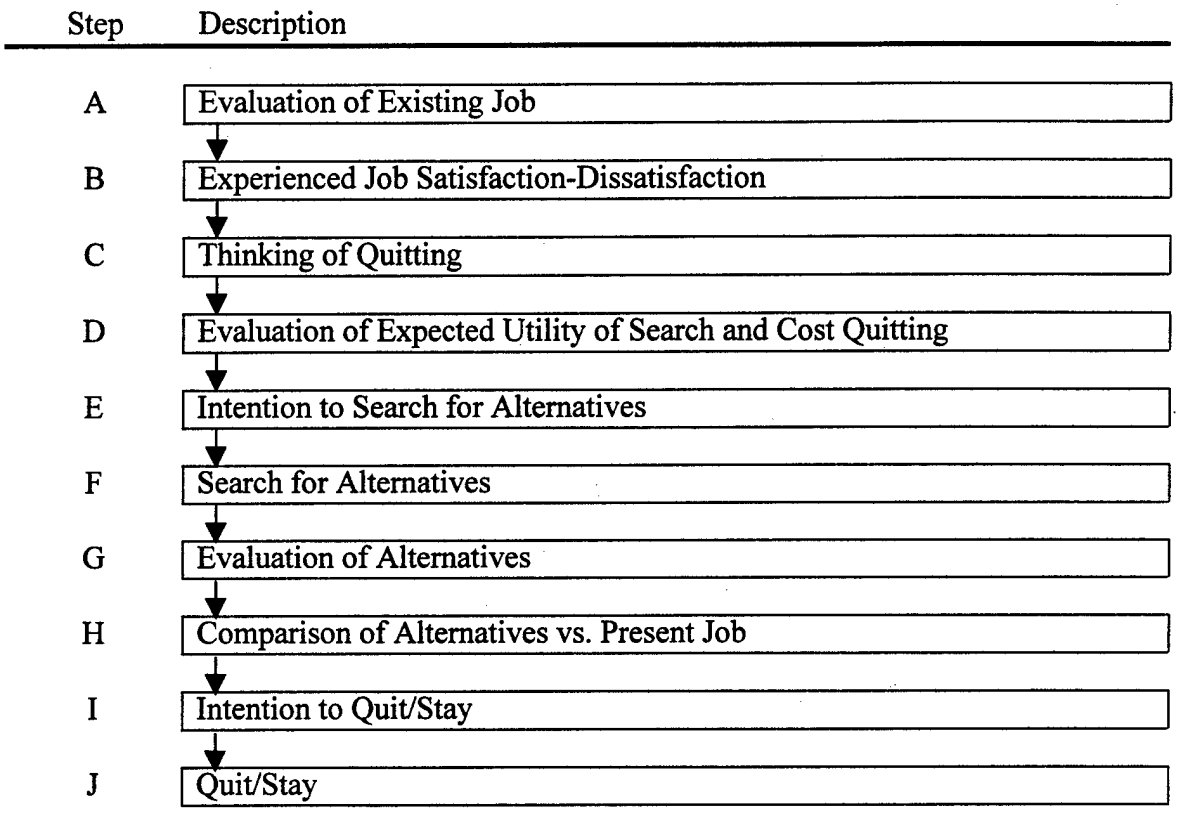

Figure 1. The employee turnover decision process (Mobley, 1977).

Looking at this process, each step leads to the next as noted by the arrows, until the employee makes his/her decision to quit or stay at the present job. If at any time that the employee finds either no reason or possibility for changing jobs, the employee then goes directly to step J, and is expected to make the Stay decision.

This thesis is proposing to concentrate on step D, where the employee evaluates the expected utility of the search process. To test this portion of the process, certain

economic indicators will be identified below that will be hypothesized to have an effect on the retention rate of the enlisted aircraft maintainer force.

Test of the Mobley (1977) heuristic

Mobley, Horner, and Hollingsworth (1978) performed a test of the Mobley (1977) heuristic where they hypothesized that the "immediate precursor of actually quitting is intention to quit" (Mobley et al, 1978: 408). This hypothesis being tested is essentially testing the movement from step I to step J in figure 1 above.

In this test, the authors interviewed and surveyed 203 hospital workers over a one-year period. The variables used in this model were taken from the heuristic developed by Mobley (1977). The variables included in this test are thinking of quitting, intention to quit, probability of finding an acceptable alternative, intention to search and the search for alternatives. The main variable of the test is the intention to quit, with all of the other variables included as they are hypothesized to be functions of intention to quit. The hypothesis is further broken down by the fact that job satisfaction has little direct effect on thinking of quitting, intending to search, and intending to quit and has no effect on turnover other than to start an employee on the path of the Mobley (1977) heuristic.

The findings of this study were that "the present results seem to indicate that both dissatisfaction and probability of finding an acceptable alternative contribute to eliciting thoughts of quitting. Elicitation of such thoughts generates intention to search" (Mobley, 1977: 412).

These finding bear directly on the present study. It is hypothesized that there are economic indicators that show the health of the economy, and these indicators will allow the employees to answer the question posed in step D in figure 1 above, what is the "evaluation of expected utility of search and cost of quitting." Using the Mobley et al (1978) study, it is expected that by answering the probability of finding an acceptable alternative, employees will either continue onto step E of figure 1 (if an acceptable alternative is expected to be found) or go directly to step J with the intention to Stay (if an acceptable alternative is not expected to be found).

Selection of variables for evaluation of search utility

To further develop the hypothesis of this thesis, it is necessary to find economic statistics that will evaluate the utility of search for employees. To do this, literature will be evaluated below that will identify variables that will be used to develop and test the hypothesis that economic indicators can be used to predict the retention rate of enlisted aircraft maintenance personnel. Two areas to be concentrated on will be what effect unemployment has on the retention rate and what effect a perception of the economy has on retention.

Unemployment rate's effect on retention

There are many things that go into an employee's decision to leave an organization. On the individual level, many variables are considered before any moves between jobs are begun. Looking at the overall movement of employees from one

organization to another, it has been found that "research focusing on aggregate labor-market statistics (e.g. unemployment rates) has consistently found these types of measures to be accurate predictors of voluntary turnover" (Steele et al., 1989, 846). The studies that Steele looked at were able to show "that labor-market conditions may explain 70-80% of the quit-rate variance" (Steele, 846). For the purposes of this study, these market conditions, specifically the unemployment rate, will be hypothesized to be a major influence to the retention rate.

The unemployment rate has a strong effect on the rate of employee turnover. Carsten and Spector (1987) researched this effect by looking at research conducted in 1982 by Skikiar and Freudenberg and found that there were numerous errors that made it "uninterpretable." Carsten and Spector (1987) hypothesized that job dissatisfaction is a predictor of turnover only when unemployment is low (Carsten, 1987, 374). By taking a second look at this data, the researchers found that this correlation did in fact exist.

Additionally, Carsten and Spector (1987) noted that there were differences between the national unemployment rate and turnover intentions and state unemployment rates and turnover intentions. The authors noted that this could be caused by differences in the unemployment rates across states. They also noted differences in the national index across various industries which may be similar to the differences across states, and that different industries could be experiencing levels of unemployment different from the national rate (Carsten, 378). In the present study, aggregated retention data and the civilian unemployment data for the United States will be used, thus reducing the geographical differences.

These studies have direct influence on the present study. In this research, it is hypothesized that as the unemployment rate increases, retention of enlisted aircraft maintainers will also increase. When the rate is high, retention rates will be high because there will be fewer jobs to attract these maintainers. When the unemployment rate is low, there will be a higher level of turnover, as job satisfaction (or unsatisfaction) will take greater importance for movement of employees. It is when unemployment is low that leadership will need to make job satisfaction higher, but when the unemployment rate is high, job satisfaction may not be a good predictor for which employees may leave. It is hypothesized that enlisted members will begin to make their decision to reenlist two years ahead of time by taking the unemployment rate into account (as part of the evaluation of expected utility of search). To test this hypothesis, a regression coefficient (β_{cu}) will be tested to see if it is significantly different from zero. This coefficient is specifically hypothesized to be greater than zero, as this would indicate that as the unemployment rate increases, the retention rate would increase. This test will be explained in chapter three of this thesis and the results of this test will be presented in chapter four.

Perception of favorable economic conditions' effect on retention

The unemployment rate must be low in real terms, and not just perceived to be low, as can happen in favorable economic times. According to Gerhart (1990), when unemployment rates are actually low, the Carsten year model can be followed. When an employee perceives the ease of movement between jobs to be easy (i.e. low

unemployment, booming economy, etc.), but that perception is false (mid to high unemployment), the employee will not leave (Gerhart, 1990, 472-473). The perception that is created by this favorable market does, however, contribute to the employee's intention to quit. If a variable to measure this intention can be found, we can therefore show a linkage from the evaluation of the existing job (step B in Mobley's (1977) model) and the evaluation of expected utility of search (step D in Mobley's (1977) model).

In Gerhart's study, he sought to find a turnover model that would take into account the market conditions and the perceived ease of movement (Gerhart, 468). This model had the intention of finding what factors would change the perception of movement. The author also sought to find out what impact, if any, skills of the employee would have on this perception. If the employee had skills that were in need by another organization, that employee would perceive an easier movement between jobs.

Gerhart found that there was a linear relationship between the turnover probability and intention to stay (Gerhart, 473). He was able to get linear results for both unemployment rates of 5% (low) and 15% (high). These two linear relationships were vastly different though, with a greater slope of the lines for the low unemployment (thus supporting Carsten's model above). He also found a linear relationship for both low and high perceptive ease of movement between job satisfaction and intention to stay. He found that when there was a high perceived ease of movement between jobs and a low job satisfaction, the intention to stay was lower than with the same job satisfaction and a low ease of movement (Gerhart, 472).

For the purposes of the present study, an economic indicator will be needed to see if a perception of easy movement is present, even if unemployment is low. It is

hypothesized that the perceptive statistic used will have a negative correlation to the retention rate, meaning that as the economy rises (according to the statistic used) the retention rate will drop. Of all the possible economic statistics, one variable will be chosen to identify possible changes in the economy that will effect retention through the perception of ease of movement (and thus increase the thoughts of quitting).

Selection of economic perceptive variable

The selection of a variable that will show a perception of the economy, and therefore show when employees are more likely to begin their thoughts of quitting, will be discussed below. First, the business cycle will be discussed, which describes the highs and lows that the economy experiences and what causes these changes. Secondly, two classes of variables will be discussed, single indicators and index indicators. Following that will be a discussion of the make-up of the leading indicator index. Finally, the interpretation of the leading indicator index and the timing involved in the use of this index will be presented.

What employees perceived in regards to the economy is where the economy is in the business cycle. The business cycle is the movement of the entire economy from periods of expansion to periods of recession (or depression) and back to expansion. The economic theory of the causes of the business cycle were proposed by Wesley C. Mitchell and Arthur F. Burns of the National Bureau in 1937. The theory is summarized by Granger (1989) in Forecasting in Business and Economics as:

(i) After a period of expansion, some parts of business begin to meet bottlenecks when trying to further expand production, such as shortages in

raw materials, specialized labor, spare parts, or capital. When this occurs, businessmen become more cautious and reduce demand for capital goods, such as machinery and equipment. They may also reduce inventories, thus causing production slowdowns, and profits can become more uncertain. There could also be reductions in overtime and hours of work and the closing down of marginal activities at the same time.

(ii) Although some parts of the economy may be showing evidence of the end of the growth phase of the business cycle, other parts will still be carried along by the considerable momentum in the economy, so that current employment and production may continue to rise, perhaps to all time highs. However, eventually the decisions to reduce investment begin to affect production and employment and the downturn experienced generally.

(iii) During the ensuing depression, production bottlenecks vanish, costs may decline and profit prospects improve, and the forces that lead to a new expansion gradually gain importance, sometimes helped by government policy decisions affecting government expenditure and interest rates. Thus, the economy begins an upturn and the cycle will eventually start to repeat itself (Granger, 1989: 168).

So it can be seen that there are movements in the economy, which may lead to the perceptions of relative ease (or lack thereof) of movement between jobs as described by Gerhart (1990) above. The next step in this process is to identify a measure that can predict the movement of the economy through these changes in the business cycle. Zarnowitz (1992) states that there is no one cause for the changes in the business cycle. There are a number of hypotheses that cause the upturns and downturns in the economy. In the prediction of these changes, there is no single chain of events that would indicate the movement in a positive or negative direction.

Therefore, it is "advisable to rely on a reasonable diversified group of leading series with demonstrated predictive potential" (Granger, 1990: 316-7). This combination of indicators into an "index" can be expected to reduce the measurement errors that may occur by using a single variable. The use of the index also reduces the "noise" that economic indicators can experience in their month to month movements. The

movements and fluctuations inherent to economics cause this "noise," particularly in the sensitive indicators.

For the purposes of this thesis, the index of 11 leading economic indicators will be utilized. This index is selected for two reasons: it is an index, and as seen above it will be a better "picture" of the economy than a single variable; and as the leading index it will identify future movements and thusly future perceptions.

What are the components that make up the leading index and why has it been chosen as the variable for noting perception? It is necessary to have a fuller understanding of what this statistic is describing. To answer this question, table 1 below lists the components that make up the index of 11 leading indicators. The leading index's components reflect:

> the degree of tightness in labor markets due to employer hiring and firing; the buildup of orders, contracts, and inventories that affect future production; materials prices that reflect shortages or gluts of raw materials for which some time will be required to expand or reduce existing inventories; and financial conditions associated with the availability of funds in credit markets and the optimism and pessimism generated by price movements in the stock market. (Frumkin, 1990: 165-6)

All of these areas covered by the index ensure that the economy as a whole is covered. This coverage should be an excellent indicator of the perception of the economy for the purposes of this thesis.

Table 1. The components of the index of 11 leading indicators

	Indicator
1.	Average weekly hours of manufacturing production workers
2.	Average weekly initial claims for unemployment insurance
3.	Manufactures new orders for consumer goods and materials industries in 1982 $
4.	Vendor performance (percent of companies receiving slower deliveries)
5.	Contracts and orders for plant and equipment in 1982 $
6.	New private housing building permits
7.	Manufacturers unfilled orders for durable goods industries in 1982 $
8.	Prices of crude and intermediate materials
9.	Stock prices of 500 common stocks
10.	Money supply (M-2) in 1982 $
11.	Index of consumer expectations

(Frumkin, 1990: 165)

This leading index is able to predict movement from one part of the business cycle from "two to 20 months" (Plocek, 1991: 312) in advance of the actual movement. This is an important aspect for the inclusion of this variable into the model proposed in this thesis. The model proposed here will attempt to predict the movement of retention rates in two years using the unemployment rate and the index of 11 leading indicators.

Summation of journal literature

These theories can all be combined to form the hypotheses for this study. Specific variables are either identified by these theories (unemployment rate) or can be deduced from them (index of 11 leading indicators).

The unemployment rate, according to Carsten and Spector (1987) and Steele (1989), is strongly related to retention. Their findings lead to adding the unemployment

rate factor into the study. It is hypothesized that the civilian unemployment rate will have a positive effect on the retention rate of the enlisted aircraft maintainers. Specifically:

H_1: As the civilian unemployment rate increases, the retention rate of enlisted aircraft maintenance personnel will also increase.

Abelson (1990) found that a person's perception of the economic conditions may or may not have an effect on the economy. To test this theory, this study will look at the index of 11 leading economic indicators. For this variable, it is hypothesized that a movement in it in the direction of a positive economy (a positive movement) will decrease the retention rate, where as a negative movement in the variable (in respect to the economy) will increase the retention rate.

H_2: As the Index of 11 leading economic indicators rises, the retention rate of enlisted aircraft maintenance personnel will decrease.

Summary and thesis hypotheses

This chapter has reviewed the journal literature regarding types and possible economic reasons for employee turnover. Presented first was an explanation and description of both avoidable / unavoidable losses and functional / dysfunctional losses. Following the classification of the turnover, potential economic "reasons" for the loss were explored.

The hypothesis for this study is that the civilian employment rate and the index of 11 leading economic indicators will have negative correlation to the retention rate. In the methodology chapter of this research (Chapter III), the method for testing this hypothesis will be explained. In the findings and analysis chapter of this research (Chapter IV), the results of the test will be presented.

III. Methodology

Introduction

This chapter will describe the procedures used in this study. First, the method of statistical regression will be described and how it is to be used. The method of data analysis to be used in this regression will follow. Next, the possible pitfalls of regression will be analyzed to ensure that the study avoids any that can be identified. The method and procedures for data collection will be identified. This chapter will finish up with the specific tests to be used in this research.

Regression

Linear regression is a tool used in statistical analysis to try and put a mathematical equation to some phenomenon that occurs between two or more pieces of information. To do this, a dependant variable (the information of interest) is selected with one or more independent (controllable or at least available) variables selected to try and describe the changes in the dependant variable. Once this step is accomplished, the process of linear regression attempts to find both the intercept and slope parameters for the equation of the regression. Step three of linear regression is to address the assumptions of the model. Step four is to address the utility of the model and the final step is to use the model for prediction and estimation.

Linear regression is a method to find a linear answer to the following equation: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$. In this equation, Y is the dependent variable that we would like to find. The X's are the independent variables that we have selected (up to

n of them). The β's are the coefficients of the independent variables and therefore the direction and level to which the independent variables affect the dependent variable. The ε term is the error term, and is used to describe the random error. This error term inclusion makes this type of regression model a probabilistic model instead of a deterministic model that would attempt to describe with exactness the movement of the dependent variable with respect to the independent variable.

To plot a linear relationship between the data points, this study will use the method of least squares. This method attempts to minimize the distance between the line and the collection of error terms (ε). To find this "best fit line" through the data, S is calculated and minimized. Here S =

$$\sum_{i=1}^{n} (\varepsilon_i)^2 \text{ or}$$

$$\sum_{i=1}^{n} (Y_i - (\beta_0 + \beta_1 X + \beta_2 X + ... + \beta_n X))^2$$

It should be noted that the process of estimating the coefficients for the independent variables is a very time consuming process if done by hand. The use of a computer with statistical software is necessary in order to find results in a timely manner. The present study will use JMP version 3.1.6.2 (1989-1996), a personal computer version of SAS developed by the SAS Institute Inc, as the statistical software to look at the data.

Assumptions for the error term of the linear regression model

The linear regression model makes four key assumptions in regards to the error term. These assumptions help to characterize the behavior of this error term. The error

term and the fact that it fulfills the following assumptions helps to ensure that the regression model accurately describes the relationship between the independent and dependent variables. These assumptions are quoted from McClave et al, Statistics for Business and Economics, 444: 1998.

> Assumption 1: The mean of the probability distribution of ε is zero. That is, the average of the values of ε over an infinitely long series of experiments is 0 for each setting of the independent variable X. This assumption implies that the mean value of Y, E(Y), for a given value of X is $E(Y) = \beta_0 + \beta_1 X$.

> Assumption 2: The variance of the probability distribution of ε is constant for all settings of the independent variable X. For our straight-line model, this assumption means that the variance of ε is equal to a constant, say σ^2, for all values of X.

> Assumption 3: The probability distribution of ε is normal.

> Assumption 4: The values of ε associated with any two observed values of Y are independent. That is, the value of ε associated with one value of Y has no effect on the values of ε associated with other Y values.

Assessing the usefulness of the model

To determine if a useful model has been found, a null and alternative hypothesis must be formed. For a linear regression model, the null hypothesis is that the coefficient of the independent variable is equal to zero. The alternative hypothesis to this null is that the coefficient is not equal to zero. The statistical equations for these are:

$$H_O : \beta_n = 0 \text{ and } H_A : \beta_n \neq 0$$

This implies that if the null hypothesis is not rejected, then the coefficient of the independent variable X_n is zero and therefore this variable does not contribute to the

changes in Y. However, if the null hypothesis is rejected, then the study can conclude that the coefficient of the independent variable is non-zero and should be included in the model.

Another method for assessing the usefulness of the linear model is to look at the coefficient of determination. This coefficient, known as r^2 "represents the proportion of the total sample variability around Y that is explained by the linear relationship between Y and X (McClave, 466). R^2 will always be a number between 0 and 1, with larger values having stronger meaning for the model. The practical interpretation of r^2 is "about $100(r^2)$% of the sample variation in Y (measured by the total sum of squares of deviations of the sample Y values about their mean) can be explained by (or attributed to) using X to predict Y in the straight-line model" (McClave, 467).

Estimation / Prediction of the dependent variable utilizing the model

Once the model has been taken through the four steps above, it is now ready for the final step. This step is to use the model to estimate and/or predict the independent variable given a value of the dependent variable. For this study, the economic statistical data will be inserted into the model, thus producing a value of enlisted aircraft maintainer retention to be compared to the actual data.

Pitfalls of regression

There are four potential pitfalls associated with the use of a linear regression model such as proposed in this study. The first potential problem with the model is

parameter estimability. The second is multicollinearity of the independent variables, the third is micronumberosity, and the final one is extrapolation. These potential problems must be identified, looked at and removed from the model if possible.

Parameter estimability has to do with the number of independent variable observations and the number of parameters (β's) to be estimated. "The number of levels of observed X values must be one more than the order of the polynomial in X that you want to fit" (McClave, 551). For the model to be examined by this study, there should be a number of data points greater than the number of parameters to be estimated in order to avoid this pitfall.

One method of determining if parameter estimability has become a problem in a linear regression model is to compare the r^2 coefficient to the adjusted r^2 coefficient. As stated earlier, the r^2 coefficient describes the amount of variability of the dependent variable "captured" by the regression model. The adjusted r^2 is the coefficient of determination adjusted for the number of independent variables. If there is no large drop in the adjusted r^2 from the r^2, then the model can be looked at as having no parameter estimability problem.

Multicollinearity of a linear regression model occurs when two or more of the independent variables in the model are themselves correlated. When this occurs, the parameter being tested for significance in the null hypothesis may very well show a significant value, but some of the independent variables may not be necessary as they may be contributing similar data. To determine if this is in fact the case with the model, a collinearity table will need to be checked. In this table, two variables are perfectly correlated if the coefficient is 1, and perfectly negatively correlated if this coefficient is

−1. As the coefficient goes toward 0, the less correlated the two variables are. If multicollinearity exists, it becomes necessary to identify this fact and identify what effects this has on the model.

Micronumerosity, or a small sample size, occurs when there are not enough data points to support the number of independent variables in the regression model. Specifically, to avoid this pitfall, the number of observations should be larger than the number of independent variables. Exact micronumerosity is when the number of observations is equal zero, "in which case any kind of estimation is impossible" (Gujararti, 1995: 326). Near micronumerosity, occurs when the number of observations is only slightly larger than the number of independent variables. Although near micronumerosity does not negate the usefulness of the regression model, it must be looked at to ensure that it is not negatively influencing the model.

Extrapolation is the use of a model beyond the "correctness" of the data that was used to determine the model in the first place. This problem is when prediction values of the dependent variable are derived from levels of the independent variable(s) that are outside the scope of those levels that were utilized in the derivation of the regression model. According to Neter, et al. (1990: 236), "the danger [of extrapolations] is that the model may not be appropriate when it is extended outside the region of the observations...[and that] it is particularly easy to lose track of this region."

Data collection and selection

As noted earlier, the first step in linear regression is selection of the data, to include both the dependent and independent variables. In the present study, the dependent variable is the retention rate among United States Air Force enlisted aircraft maintenance personnel. The independent variables chosen are the economic statistics noted in Chapter 2.

The retention data was collected from the retention office of AFPC. This data is collected annually and is broken down by type of reenlistment and by AFSC. The types of reenlistments are first term reenlistments, second term reenlistments and career reenlistments. Of these, the first and second term reenlistment statistics are to be utilized as the dependent variables of this study. From this data, the rate of retention of personnel is expressed as a percentage of the number of personnel who reenlist from those who are qualified to reenlist.

The economic data that was collected was taken from the economagic web page, www.economagic.com. This web page is a collection of economic statistics collected by the government and other outside groups. The data collected by these groups is compiled by the month. To be able to compare this monthly data to the annual retention data, it is necessary to "annualize" the economic statistics. To do this, a simple average for each year was computed. Table 2 lists the economic statistics, with the group who collects the statistics and the time frame of the collection.

Table 2. Economic statistics

Economic Statistic	Who Collects	When Collected
Civilian Unemployment rate	Bureau of Labor Statistics	Monthly
Index of 11 leading indicators	Bureau of Economic Analysis	Monthly

Lagging the data

In Cromer and Juliher's study of pilot retention (1982), they noted that pilots had a lag between the time that a pilot decided to leave the Air Force and the time that they actually did leave the Air Force. These authors decided that this lag should be performed because officers are required by personnel regulations to give six months notice.

The present study proposes to perform a similar "lag" of the retention data for two reasons: notice must be given by enlisted personnel as with the officers in the Cromer study and the economy (which has a hypothesized effect on retention as per Gerhart's study above) may take longer than a "snapshot" in time to have an effect on retention. Makridakis, Wheelright and Hyndman (1998) describe this as a dynamic regression. They note that "sometimes the effect of a change in an explanatory variable does not show up in the forecasted variable instantaneously, but is distributed across several time periods" (403).

Reenlistment actions do not take place the day that one enlistment ends. The reenlistment process begins with the selective reenlistment program, which is produced 15 months before the enlistment ends. Once this is accepted by the unit commander, the member will receive a career job reservation from two to ten months later. This career

job reservation will reserve the member's job, though it is not the actual reenlistment. Both of these actions show that the member must begin thinking about the pending reenlistment over a year ahead of the actual reenlistment, and thus a model that uses lagged data is appropriate.

Gerhart's (1990) study indicated that the perception of the economy may have an effect on the perceived ease of movement between jobs. This awareness of the health of the economy is not hypothesized to be derived from one indicator alone, but a combination of factors. These factors are selected the day of reenlistment, but affect the perception of the economy for some time in the preceding months before reenlistment. To determine if this perception is in fact building on previous information, a looking at those years will be built here to identify any relationship between previous year economic data and corresponding retention data.

This study does not have the data in biannual data points, which would allow the six months move in time as was done in the Cromer study. Therefore, I will move the data one and two years. To accomplish this, the dependent variable will be paired with the independent variables of the previous year (or two years prior for the two-year lag). It is hypothesized that this will not only provide a model that will be utilized for the present year, but also for each of the next two years.

Specific model to be tested

The hypothesis for this research is that the economy has a negative effect on the retention rate of enlisted aircraft maintenance personnel. Specifically, it is hypothesized

that when there are favorable economic conditions (as measured by the index of 11 leading indicators), the retention rate will lower and when there are poor economic conditions, there will be a rise in the retention rate. To show this, a model will be built using economic statistical data as independent variables and retention rates as the dependant variable. The model to be built will lag the dependant variable two years. The specific independent variables selected for these models were discussed in Chapter 2. The models (for both 1st term and 2nd term reenlistments) are below with an explanation of what each variable and coefficient is.

$$Y_i = \beta_0 + \beta_{cu} X_{cu} + \beta_{LEI} X_{LEI} + \varepsilon$$

Y_{rrx} = retention rate lagged two years, with the x=1 for 1st term and x=2 for 2nd term reenlistments
β_0 is the Y intercept for the model
β_{cu} is the coefficient for the Civilian Unemployment variable
X_{cu} is the Civilian Unemployment variable
β_{LEI} is the coefficient for the index of 11 Leading Economic Indicators
X_{LEI} is the index of 11 Leading Economic Indicators variable
ε is the error term

The test for the hypothesis using this model will be:

H_o: $\beta_{cu} = \beta_{LEI} = 0$

H_a: $\beta_{cu} > 0$, $\beta_{LEI} < 0$

Summary

This chapter has detailed the method for testing the hypothesis of this thesis. Linear regression has been explained, including the steps for completing it, the assumptions made, and the pitfalls that exist in its implementation. The method of data

collection for the study, as well as what modifications to be done to this data was described.

IV. Findings and Analysis

Introduction

In this chapter, I will discuss the regression models built to test the following hypothesis: that there is a negative relationship between the economy (as evidenced by the civilian employment rate and the index of 11 leading economic indicators) and retention rates of enlisted aircraft maintenance personnel. The linear equations and the statistics that support (or do not support) the hypothesis will be presented first. Then the regression information of the models (1st term and 2nd term retention rates as the dependent variables) and any problems or deviations that occur with them will be discussed. Next, a discussion of how the pitfalls of regression that were presented in chapter three are controlled (or not controlled) in each model will be presented. Finally, an analysis of the entire test will be conducted.

Selected model for base year

The regression function as presented in chapter three is $Y_i = \beta_0 + \beta_{cu} X_{cu} + \beta_{LEI} X_{LEI} + \varepsilon$. The results of the regression are based on retention rate data from 1991-1998 and economic data from 1988-1996. This data can be found in appendix B. The regression results for 1st term reenlistments are located in Tables 2, while table 3 has the 2nd term reenlistments results.

Usefulness of the models

The first and most important thing that must be discussed in regards to the usefulness of these models is the ability of each to answer the hypothesis set forth. The null hypothesis of the model here is that all of the coefficients for each of the independent variables are equal to zero, thus indicating that the independent variables have no relation ship to the dependent variable. The alternate hypothesis is that they are not equal to zero, specifically that the civilian unemployment rate will have positive relationship and the index of 11 leading economic indicators will have a negative relationship. All coefficients for both models are significant at the 0.05 level.

This significance indicates that a relationship exists between the independent and dependent variables. The sign of each of the coefficients for the independent variables indicates the type of relationship. In both models, the civilian unemployment rate has a positive relationship. This is the hypothesized direction of movement, indicating that when unemployment rises the retention rate also rises. This is consistent with the journal literature of Steel (1989) and Carsten and Spector (1987).

The sign of the coefficients for the index of 11 leading economic indicators in both models is negative, again agreeing with the hypothesis. This means that as the index rises (indicating a future positive movement in the economy) turnover will also be expected to rise. This too is consistent with the journal literature presented by Gerhart (1990), that stated that the economy must actually be flourishing before unemployment's effect on turnover can be fully realized.

The second method for assessing the usefulness of the model is to look at the r^2 value. The adj. r^2 value listed in table 2 is 0.981, indicating that this model is describing 98.1% of the sample variability in the retention rate. The adj. r^2 value of 0.802 is listed in table 3, indicating that this function describes 80.2% of the variability. These findings are even stronger than 70-80% that was hypothesized by Steel (1989) as noted in chapter two of this study.

With these high r^2 values and significant coefficients, both of these equations show a strong relationship in the hypothesized manner between the economy and the retention rates of first and second term enlisted aircraft maintainers. Furthermore, it is interesting to note a difference between the predicative ability of the model for 1st term reenlistments and 2nd term reenlistments. The 1st term reenlistment model would seem to show that these personnel are more affected by the changes in the economy than the 2nd term reenlistment personnel. This may be due to the differences in rank, marital status and number of dependents that take place during the second enlistment.

Estimation and prediction of the model

To check the estimation and prediction ability of these models, a regression function will be built using the coefficients and intercepts from the regression analysis. The coefficient and intercept data is taken from table 2, yielding the function:

$Y_{p1} = 105.88004 + (5.1974282)\ X_{cu} + (-0.783146)\ X_{LEI}$, where Y_{p1} is the predicted value of the retention rate given by the equation. After substituting the independent variables for each year, it is possible to compare the predicted retention rate

to the actual retention rate. In Figure 2, the actual and predicted retention rates are compared year to year, and by looking at this graph, the regression equation seems to accurately capture changes in the retention rate.

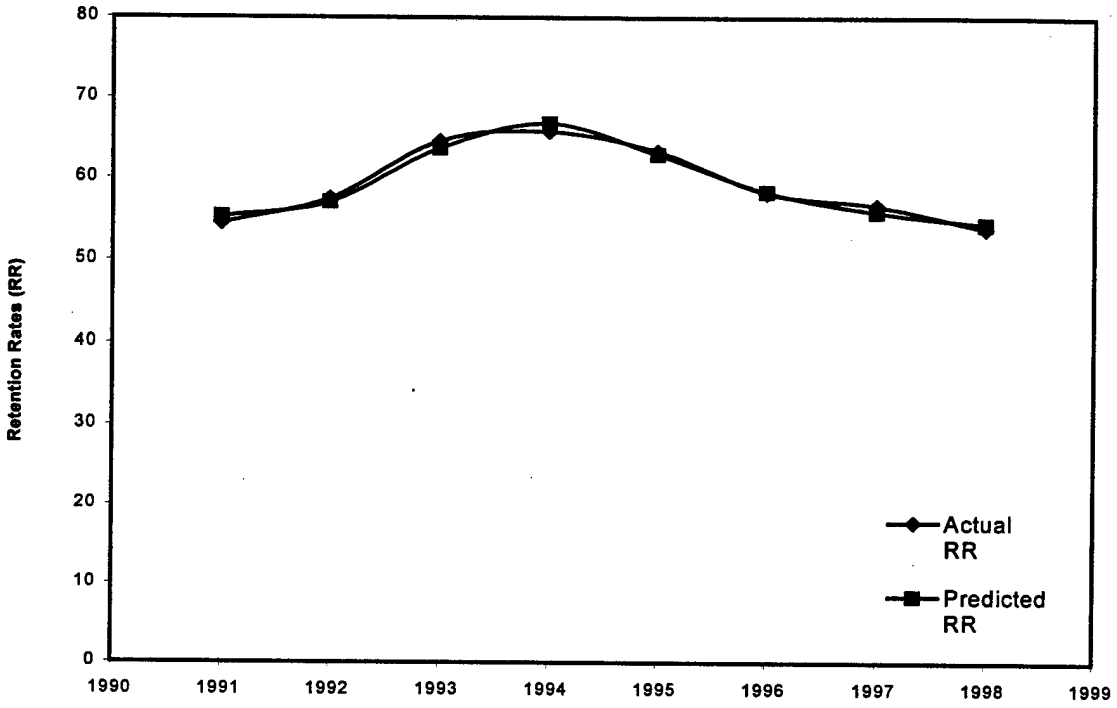

Figure 2. Comparison of the predicted and actual 1st term retention rates

Table 3. Regression analysis using 1st term reenlistment as the dependent variable

Variable	β	Stnd β	SE β	p-Value
Intercept	105.88	0	23.55	0.0064
Civilian Unemployment	5.20	0.9293	0.297	<0.0001
Index of 11 leading economic indicators	-0.78	-0.1817	0.229	0.0189

Note: Adj. $r^2 = 0.987$; $p < 0.0001$

For the 2nd term reenlistments, Table 3's information was used to design the regression equation: $Y_{p2} = 293.79847 + (4.5645718)\ X_{cu} + (-2.449171)\ X_{LEI}$. Again, the predicted retention rates given by the model follows closely the actual retention rate. Figure 3 shows how the predicted retention rate mimics the movement of the actual retention rate.

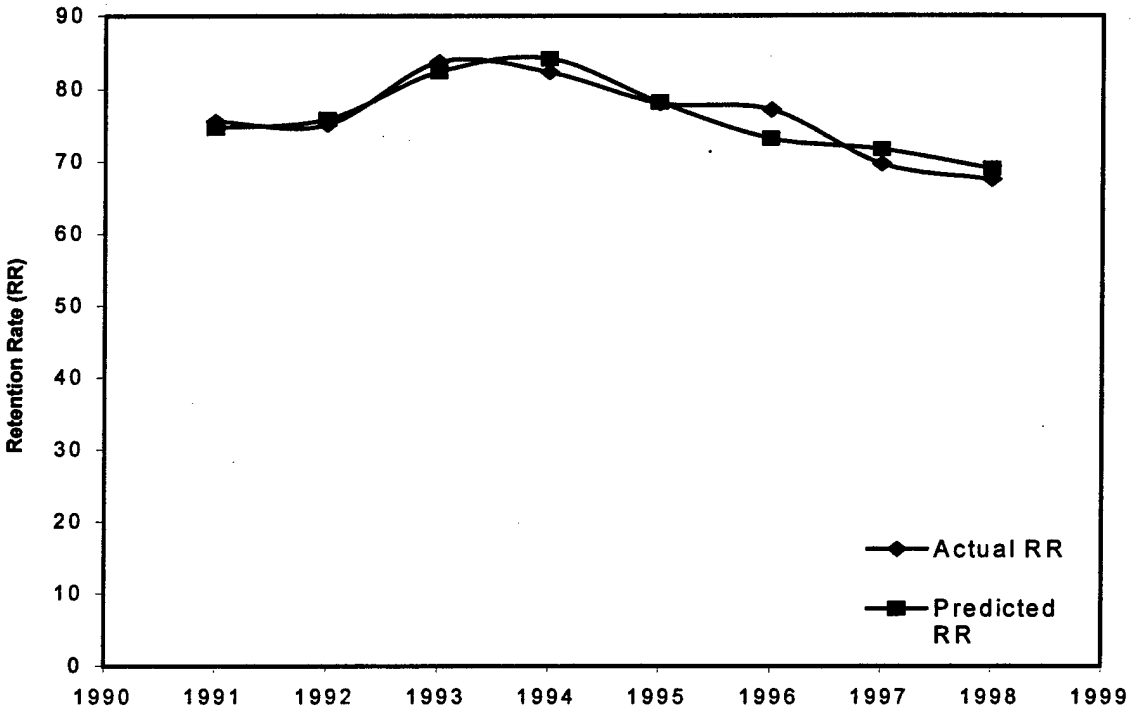

Figure 3. Comparison of the predicted and actual 2nd term retention rates

Table 4. Regression analysis using 2nd term reenlistment as the dependent variable

Variable	β	Stnd β	SE β	p-Value
Intercept	293.80	0	92.89	0.0250
Civilian Unemployment	4.56	0.680	1.17	0.0115
Index of 11 leading economic indicators	-2.45	-0.473	0.90	0.0423

Note: Adj. $r^2 = 0.802$; $p < 0.01$

Pitfalls of regression and the models

Before these models can be truly found to be useful, the potential pitfalls of linear regression must be addressed, and controlled for if necessary. These pitfalls are parameter estimability, multicollinearity, micronumerosity, and extrapolation. Control of these pitfalls, or at least having the knowledge that they may exist in these models will ensure that no inappropriate claims are made with this data.

Each of these models has avoided the parameter estimability pitfall. There must be more data points used in the regression than there were independent variables to ensure that parameter estimability is not a problem. Each function was built using eight data points and only two independent variables. The method of testing for this in the model was to look at the difference between the r^2 and adjusted r^2 values. A drop of 0.1 or greater may show that this problem has entered into the model. As seen in the table 8, there has been no such drop in any of the models.

Table 5. Model r^2 and adjusted r^2

Model	r^2	Adjusted r^2
1st Term reenlistment	0.987	0.982
2nd Term reenlistment	0.858	0.802

Multicollinearity in a regressive function is when two independent variables are acting at the same time and in the same manner on the dependent variable. To test for this, a correlation coefficient is produced to determine if this exists between the variables. Table 6 lists the variables and the correlation coefficient between themselves and the dependent variables.

Table 6. Correlation coefficients

Variable	1st term reenlistment	2nd term reenlistment	Index of 11 leading indicators	Civilian unemployment
1st term reenlistment	1.0000	0.8578	-0.4301	0.9779
2nd term reenlistment		1.0000	-0.6551	0.8064
Index of 11 leading indicators			1.0000	-0.2673
Civilian unemployment				1.0000

The correlation coefficients between the independent variables show little to no multicollinearity. If this value (-0.2673) were to be considered too high, that would not preclude use of the models. Neter (1996) states "the fact that some or all predictor variables are correlated among themselves does not, in general, inhibit our ability to

obtain a good fir not does it tend to affect inferences about... predictions of new observations" (1996: 289). Neter (1996) also states that the individual coefficients of the independent variables may not be significant by themselves, but "a definite statistical relation exists between the response variable and the set of predictor variables" (290). Finally, Neter finds that the common interpretation of the coefficients of the variables cannot be used when multicollinearity exists. The equation, if statistically significant, can still be used as a predictive device, as long as the range of the input independent variables is within the range that was used to build the function originally.

Micronumerosity was a major concern when the size of the data here is considered (only 8 dependent variable data points available). With this number of data points (8), it may be difficult to avoid this pitfall, so a test to see if it has occurred after determining the equations is necessary. To test for micronumerosity, a look at the r^2 and adjusted r^2 is necessary to see if the large number of independent variables (large for the size of the data) is affecting the model. As you can see in the table above, there is no significant movement between the r^2 and the adjusted r^2 values, showing that we may have avoided this pitfall.

Extrapolation can occur when we try to use a model to predict that which it is not been built to predict. If this model is to be used to predict for a future year's retention rate, the economic data that is input into the model must be verified as being within the relevant range used to construct this model.

Analysis

The analysis of the findings of this thesis is broken down into two areas. The first area to be looked at is the correlations between the independent and dependent variables. The second area for analysis is the comparison of the rates and models of the 1st and 2nd term reenlistments will be conducted to try and determine if and why there is a difference between the models and why there must be two different models.

Taking a closer look at Table 6, the correlation coefficients between each of the variables can be looked at and all of the relationships can be analyzed. The correlation coefficient is a bivariate relationship that "describes a relationship between two variables" (McClave et al, 1998: 461). A perfect relationship can be either positive or negative and is noted by the closeness to either +1 or –1. All of the variables have a perfectly positive relationship with themselves (as evidenced in Table 6). As the correlations get closer to 0, there is little relationship (or no relationship if correlation is 0) between the variables.

The civilian unemployment rate shows the highest correlation between the two dependent variables. This is consistent with the journal literature which indicated that the unemployment rate was a good indicator of the level of turnover to be expected by an organization. It is also important to note that the correlation between the variables is positive, which also indicates that the model is following the hypothesized directions. The unemployment rate has a higher relationship to the 1st term reenlistments (0.9779) than it does to the 2nd term reenlistments (0.8064), which may indicate that (as was

indicated by the r^2 discussion above) there may be other variables affecting the 2nd term reenlistment rate than there are working on the 1st term rate.

The index of 11 leading indicators shows a moderate correlation between the two dependent variables. This moderate correlation is also consistent with the literature, which indicated that perceptions of the health of the economy would possibly lead to the employees beginning to evaluate the expected utility of a job search (step D of Mobley's (1977) turnover decision model (Figure 1)). These correlations are also negative, the hypothesized direction for the perceptive variable. The relationship for this variable is stronger for the 2nd term reenlistments (-0.6551) than for the 1st term rate (-0.4301). This may be an indication that the components of the index begin to affect an older individual more than a younger individual (expected that 1st term members are early 20's and 2nd term members are late 20's or early 30's).

A final look at the correlation between the independent variables themselves shows that there is little correlation between them. The correlation coefficient is only –0.2673, which is the lowest of any of the correlations of any of these variables. Added to this, Tabachnick and Fidell (1996) note that when a composite variable is constructed by several individual items, the correlation between the composite variable and related variables may be inflated. One of the indicators used to make the index of 11 leading economic indicators is the average weekly initial claims for unemployment insurance. Although this is not the same as the civilian unemployment rate, there is a definite relationship between these two indicators, which may be causing some of the correlation between the index and the civilian unemployment rate. The correlation is mitigated by

the fact that there are 10 other mostly unrelated indicators used in the computation of the index.

When looking at the 1st and 2nd term models there are two areas that can be looked at to identify differences in them and why there should be two models built to describe the movements of these two variables. The first area is the actual retention data differences between the 1st and 2nd term reenlistments. The second area is to look at the r^2 values and identify if there is a difference in the two models.

There are three major assumed differences between 1st and 2nd term enlistees that may account for the differences in the retention rates in these two groups, and why the researcher felt that a model for each group was necessary. The first assumption is the age difference: it is assumed that 1st term reenlistees are four to six years younger than 2nd term reenlistees. Most 1st term reenlistees are expected to be approximately 22 to 24 years old. This coincides with a 1st term enlistment of four to six years that starts while the member is 18 years old. In a study of 21,000 workers in 1977, Haber, Lamas, and Green (1983) found that workers age 18 to 24 have a separation rate of 36.4%. Second term reenlistees, who can be expected to be aged 26-30, should fall in the next category described by Haber (1983) was 25 to 44, and the rate was 15.6%. This drop in half shows that there may be a significant difference between the two groups.

The next assumption is that 1st term enlistees are less likely to be married. Although this assumption is not as strong as the first, there is still a significant difference noted in the Haber (1983) study. Married personnel in this study had a separation rate of 13.3%, where as single people had a turnover rate of 29.0%. Once again, the assumptions used here indicate that the expected differences between the groups may

cause a different variable to be introduced (marital status) and confound any findings between the groups and necessitate breaking them out into separate models.

The final assumption concerning the raw data is the presence of children. First term enlistees are expected to have younger children (if any), where as 2nd term enlistees are expected to have older children. Families with children under age six have a separation rate of 20.9%, where as families with children between the ages of six and 17 have a separation rate of only 10.7%. First term enlistees, with the younger children, are therefore expected to be more mobile workers than 2nd term enlistees with the older children.

All three of these assumptions indicate that there should be an expected difference between the two groups. All of these assumptions, using the Haber (1983) data, show significant (rates drop in half) differences between the two groups. With these types of differences, the production of two models is supported.

These assumptions and differences between the two groups also may indicate the differences in the findings of the two models. As noted earlier in this chapter, the different independent variables are expected to affect the two groups differently. As can be seen by the correlation coefficients, the groups are affected differently by these variables.

The assumptions of differences between the groups presented above may also indicate the differences in the prediction power of the two models. The model for the 1st term reenlistments has an adjusted r^2 value of 0.981, indicating that the economic variables are able to describe and predict the retention rate 98.1% of the time. The model for the 2nd term reenlistments has an adjusted r^2 value of 0.802, indicating that the

economic variables in the model are able to describe and predict the retention rate 80.2% of the time. The drop in these two r^2 values is probably due to the fact that the assumptions are being followed, with personnel getting older, married and having children. All of these additional variables are not accounted for in the regression equation and lower the predictability of the model.

Summary

This chapter has presented the findings and results of the research into the economy's effect on the retention rate of enlisted aircraft maintenance personnel. The economic data was statistically shown to affect the retention rate and explain some of the variability. After these models were presented, the predicted values of each of the models was compared to the actual values that were used to build the model, all showing a strong similarity. The four pitfalls of linear regression were discussed and shown to not affect any of these models. Finally, an analysis of the two models was discussed, addressing the correlations between the variables and the differences between the dependent variables and their models.

V. Conclusions and Recommendations

Introduction

This chapter will summarize the conclusion of the analysis and prediction of enlisted aircraft maintenance personnel retention rates using economic statistics. As part of this conclusion, possible applications of this research will be focused on. Future research in similar areas of turnover will then be suggested.

Conclusions

In Chapter I, the problem statement for this thesis was to investigate the effects of certain national economic conditions and indicators on enlisted aircraft maintenance personnel retention rates. To test this problem, the researcher hypothesized that there was a positive correlation between the retention rate of enlisted aircraft maintainers and the civilian unemployment rate and a negative correlation between this retention rate and the index of 11 leading economic indicators.

The results presented in Chapter IV, as well as those listed in Appendix A, indicate that there is a strong relationship between certain economic indicators and the retention rate of the Air Forces enlisted aircraft maintenance personnel. Specifically, the civilian unemployment rate and the index of 11 leading economic indicators, when lagged two years, have been shown to be excellent predictors of the retention rate for both 1st and 2nd term airmen. These variables are able to predict 98.1% of the variability in retention rates of 1st term airmen and 80.2% of the variability in the retention rates of

2nd term airmen. The unemployment rate, as predicted by the journal literature presented, was shown to be an accurate variable in the prediction of these retention rates, and was the stronger independent variable for both models in terms of significance.

This study was undertaken because, as was noted in chapter 1, the Air Force has identified retention of quality personnel as a major problem. An important step to solving any problem is to identify any and all causes of the problem. The results of this study should identify, at least in its limited scope, a probable cause of the retention rate problem being experienced. This study has shown that if it is possible for the Air Force to identify the number of people it wants in its force in two years, it should be able to predict how many of the present ranks will be there at that time.

Recommendations

There are three areas of recommendations for applicability of this study and for further research to build on this study. The use and improvement of the models presented here is the first recommendation. Expansion of the field of retention information is the second area. Finally, a look at the effects to the operations of the Air Force that are caused by changes in retention rates should be researched.

The relative inability to predict low retention rates makes it nearly impossible to ensure the proper strength of the Air Force. The Air Force Personnel Center (AFPC) knows the end strength requirements necessary to fill all spots in the force. By using these models, AFPC could better predict the retention rates of the enlisted aircraft

maintainer force and either employ some method to influence the rate (increase / decrease the bonus for the career) or modify the recruiting goals for these career fields.

Improvement of these models, if they are used, is necessary to ensure that they are as accurate as possible. By getting the next year's data for the applicable statistics, the regressive models could be improved and refined. The addition of more data points to the present models will increase their prediction capability by making changes in the coefficients. Future movements of the relationship between the economic data and the retention data should cause the improvement in the regression equations.

Expansion of this field of research should take two routes: direct expansion of this study into other career fields and the impact on retention rates of changes in compensation. The first expansion of this study should be to look at other career fields in the Air Force to see if a similar relationship exists to the economy as this study has shown to exist in the aircraft maintenance career field. A major area to look at should be to look at the pilot community, as this is a "hot topic" in today's force.

Another expansion of this study would be to see what impact (if any) changes in compensation have on the retention rate. These changes could include significant pay increases (above and beyond the "normal" yearly increase), bonus rates for reenlistment, and changes in the retirement benefits. These changes in compensation are contemplated in Congress and AFPC to increase the retention rate, so a model that can discover any relationship to past changes could be helpful in deciding if they are an effective means of raising the retention rate.

A final area of recommendation for the further study in this area is to look at what effects retention has on the metrics of the Air Force. On the operational side of the Air

Force, a look at the effects that changes in retention rates of maintenance personnel have on aircraft Mission Capable (MC) rates should be conducted. In a similar study, these same rates could be tested against the retention rates of the pilots of these same aircraft. This comparison of MC rates to the retention rates of the pilots may indicate if there is a relationship between the age and experience of the pilots and how they treat the aircraft (younger, less experienced pilots may do more harm to aircraft than older, more seasoned pilots). Other metrics that could be tested are service times and customer satisfaction for some career fields and the retention rates of these employees.

Thesis summary

In conclusion, the Air Force has identified that it, as with any employer, has a major problem with employee retention. The problem is being addressed by the Chief of Staff in four areas: (1) OPTEMPO, (2) family care for deployed personnel, (3) quality of life, and (4) personnel problems. This thesis has identified that there are many other factors that affect the turnover in the enlisted aircraft maintainer career fields. This research has found that there is a strong relationship between the fluctuations of the economy and the fluctuations in the retention rate of these personnel.

Appendix A. Regression data

This appendix presents the regression tables for the regression equations. The dependent variable for the model is listed above the results.

1st term reenlistment rate

Summary of Fit

r^2	0.986873
Adjusted r^2	0.981622
Root Mean Square Error	0.628088
Mean of Response	59.28875
Observations	8

Parameter Estimates

Term	Estimate	Std Estimate	Std Error	t Ratio	Prob>|t|
Intercept	105.88004	0	23.55255	4.50	0.0064
Civilian Unemployment	5.1974282	0.929293	0.297399	17.48	<.0001
Fed Funds Rate	-0.783146	-0.18169	0.229199	-3.42	0.0189

Effect Test

Source	N parm	DF	Sum of Squares	F Ratio	Prob>F
Civilian Unemployment	1	1	120.48685	305.4213	<0.0001
Fed Funds Rate	1	1	4.60574	11.6750	0.0189

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	148.28542	74.1427	187.9438
Error	5	1.97247	0.3945	Prob>F
C total	7	150.25789		<.0001

2nd term reenlistment rate

Summary of Fit

r^2	0.858307
Adjusted r^2	0.80163
Root Mean Square Error	2.477147
Mean of Response	76.15625
Observations	8

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	293.79847	92.89013	3.16	0.0250
Civilian Unemployment	4.5645718	1.172926	3.89	0.0115
Fed Funds Rate	-2.449171	0.903951	-2.71	0.0423

Effect Test

Source	N parm	DF	Sum of Squares	F Ratio	Prob>F
Civilian Unemployment	1	1	92.931456	15.1446	0.0115
Fed Funds Rate	1	1	45.045577	7.3409	0.0423

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	185.85290	92.9265	15.1438
Error	5	30.68129	6.1363	Prob>F
C total	7	216.53419		0.0076

Appendix B. Economic and retention data

This appendix lists the economic and retention data used to develop the models described in this study.

	Retention Rate				Economic Statistics	
	Original Data		Data Lagged 2 Years			
Year	1st Term	2nd Term	1st Term	2nd Term	Index of 11 leading indicators	Civilian Unemployment
1988			46.87	63.92	100.3	5.49
1989			54.47	75.59	99.63333	5.26
1990	46.87	63.92	57.48	75.12	99.18333	5.62
1991	54.47	75.59	64.56	83.70	99.03333	6.85
1992	57.48	75.12	65.77	82.32	100	7.49
1993	64.56	83.70	63.33	78.09	100.475	6.91
1994	65.77	82.32	58.19	77.16	101.3917	6.10
1995	63.33	78.09	56.65	69.72	100.8833	5.60
1996	58.19	77.16	53.86	67.55	102.0667	5.40
1997	56.65	69.72			103.7556	4.94
1998	53.86	67.55			105.7278	4.48

Bibliography

Ableson, Michael A. "Examination of Avoidable and Unavoidable Turnover," Journal of Applied Psychology, 72: 382-386 (No. 3).

Buddin, Richard, Daniel S. Levy, Janet M. Hanley, and Donald M. Waldman. Promotion Tempo and Enlisted Retention. RAND, R-4135-FMP (1992).

Carsten, Jeanne M. and Paul E. Spector. "Unemployment, Job Satisfaction, and Employee Turnover: A Meta-Analytic Test of the Muchinsky Model," Journal of Applied Psychology, 72: 374-381 (No. 3).

Clayton, Gary E. and Martin G Giesbrecht. A Guide To Everyday Economic Statistics. New York: McGraw-Hill, Inc. 1992.

Cromer, DeJuan and Mark R. Julicher. An Examination of the Effects of Economic Conditions on Pilot Retention. MS thesis, LSSR 38-82. School of Systems and Logistics, Air force Institute of Technology (AU), Wright-Patterson AFB OH, September 1982

Dalton, Dan R., David M. Krackhardt, and Lyman W. Porter. "Functional Turnover: An Empirical Assessment," Journal of Applied Psychology, 66: 716-721 (No. 6).

Frumkin, Norman. Guide to Economic Indicators. Armonk, New York: M. E. Sharpe, Inc., 1990.

Gerhart, Barry. "Voluntary Turnover and Alternate Job Opportunities," Journal of Applied Psychology, 75: 467-476 (No. 5).

Granger, C. W. J. Forcasting in Business and Economics (Second Edition). Boston: Academic Press, Inc., 1989.

Gujararti, Damodar N. Basic Econometrics (3rd edition). New York: McGraw-Hill, Inc., 1995.

Haber, Sheldon E., Enrique J. Lamas, and Gordon Green. "A new method for estimating job separations by sex and race," Monthly Labor Review, 106: 20-27 (Jun 83).

Hickey, Amy. "Military Leaders Hope New Concept Will Improve Retention," Air Force News, WWWeb, http://www.af.mil/news/Aug_1998/n19980826_981282.html (Aug 1998).

McClave, James T., P. George Benson, Terry Sincich. Statistics: For Business and Economics (4th edition). Upper Saddle River, New Jersey: Prentice Hall 1998.

Mobley, William H. "Intermediate Linkages in the Relationship Between Job Satisfaction and Employee Turnover," Journal of Applied Psychology, 62: 237-240 (No. 2).

Mobley, William H., Stanley O. Horner and A.T. Hollingsworth. "An Evaluation of Precursors of Hospital Employee Turnover," Journal of Applied Psychology, 63: 408-414 (No. 4).

Neter, John, Michael H. Kutner, Christopher J. Nachtsheim, and William Wasserman. Applied Linear Statistical Models (4th edition). Chicago: Irwin 1996.

Plocek, Joseph E. Economic Indicators: How America Reads Its Financial Health. New York: New York Institute of Finance, 1991.

Ryan, General Michael E. "Special Interest NOTAM: Retention," 11 Dec 97.

Steele, Robert P. and Rodger W. Griffeth. "The Elusive Relationship Between Perceived Employment Opportunity and Turnover Behavior: A Methodological or Conceptual Artifact?" Journal of Applied Psychology, 74: 846-854 (No. 6).

Tabachnick, Barbara G. and Linda S. Fidell. Using Multivariate Statistics (Third Edition). United States of America: Harper Collins College Publishers, 1996.

Welch, Finis. "Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust," Journal of Political Economy, 87: S65-S98

Zarnowitz, Victor. Business Cycles: Theory, History, Indicators, and Forecasting. Chicago: The University of Chicago Press, 1992.

Vita

Captain Pete Lommen was born 1 June 1971 in Edina Minnesota. He graduated from Walterboro High School in Walterboro South Carolina in 1989. He entered the United States Army on 2 Jan 1990 as an Apache attack helicopter repairer. He is a 1991 graduate of The United States Military Academy Preparatory School. On 31 May 1995 he was appointed a second lieutenant in the Air Force and graduated from The United States Air Force Academy with a B.S. in Geography.

Captain Lommen was assigned to Pope AFB NC from Aug 1995 through April 1998. While there, he was a member of the Blackcats of the 41st Airlift Squadron. As a maintenance officer in the Blackcats, he worked as the Sortie Support and Sortie Generation Flight Commander. Before attending the Air Force Institute of Technology, he was the 41st Airlift Squadron Section Commander.

Captain Lommen is married to the former Shannon Maria Nettles. They have two children, Reagan Elizabeth age 2 and Preston Scott age 9 months. They will be stationed at Travis AFB CA following graduation from AFIT.

Permanent Address: 129 Underhill Road
Walterboro SC 29488

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

Public reporting burden for this collection of information is estimated to average 1 hour per reponse, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducting this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1999	Master's Thesis

4. TITLE AND SUBTITLE

A METHODOLOGY FOR THE ANALYSIS AND PREDICTION OF AIR FORCE ENLISTED AIRCRAFT MAINTENANCE PERSONNEL RETENTION RATES USING ECONOMIC STATISTICS

5. FUNDING NUMBERS

6. AUTHOR(S)

Peter D. Lommen, Captain, USAF

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

Air Force Institute of Technology
2950 P Street
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GLM/LAL/99S-8

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

ASC/CC

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

A

13. ABSTRACT (*Maximum 200 Words*)

The purpose of this study is to investigate the effects of certain national economic indicators on enlisted aircraft maintenance personnel retention rates. To fulfill this purpose, this study builds a linear regression equation that can predict the retention rate using the civilian unemployment rate and the index of 11 leading economic indicators as the independent variables. Journal literature and economic texts were reviewed to identify the indicators as good predictors for changes in employee turnover.

The method of linear regression was used to build the model needed to predict the changes in the retention rate. The equation developed with this technique in the present research may help the Air Force Personnel Center predict future enlisted retention rate changes. AFPC's task of keeping a steady force has a central need of knowing the number of personnel that will be staying and leaving the force.

The results of this study show a strong relationship between the future retention rate of the enlisted aircraft maintenance force and the unemployment rate and the index of 11 leading indicators.

14. Subject Terms	15. NUMBER OF PAGES
Enlisted Retention, Linear Regression, Economic Statistics	66
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

AFIT Control Number _____

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. **Please return completed questionnaire** to: AIR FORCE INSTITUTE OF TECHNOLOGY/ ENA 2950 P STREET, WRIGHT-PATTERSON AFB OH 45433-7765. Your response is **important.** Thank you.

1. Did this research contribute to a current research project? a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?
a. Yes b. No

3. **Please estimate** what this research would have cost in terms of manpower and dollars if it had been accomplished under contract or if it had been done in-house.

Man Years_____ $_____

4. Whether or not you were able to establish an equivalent value for this research (in Question 3), what is your estimate of its significance?

a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments (Please feel free to use a separate sheet for more detailed answers and include it with this form):

_____ _____
Name and Grade Organization

_____ _____
Position or Title Address