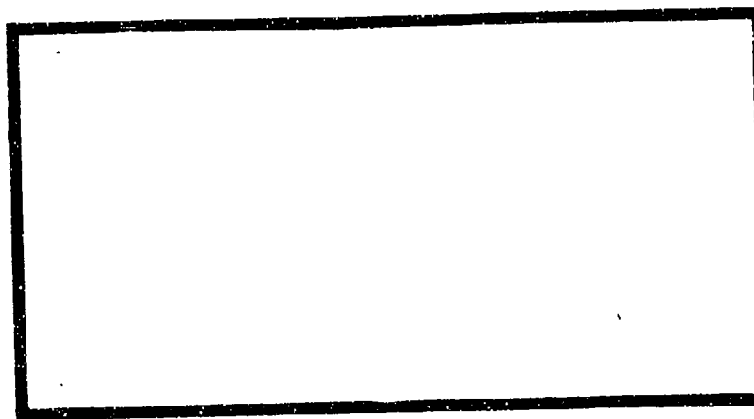


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AN EXAMINATION OF THE EFFECTS OF
ECONOMIC CONDITIONS ON PILOT RETENTION

DeJuan Cromer, Captain, USAF
Mark R. Julicher, Captain, USAF

LSSR 38-82

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→ This study investigates the effects of economic conditions on pilot retention. The basis for the analysis is that the pilot is an individual whose decision-making process is based on perceptions derived from various economic influences. Based on this "economic man" assumption, the researchers hypothesized that certain economic conditions are highly correlated with pilot retention. A factor analysis and several multiple regression analyses were performed to investigate the relationship between selected economic variables and pilot retention rate. Aggregate economic factors as independent variables produced low coefficients of determination (Adjusted R^2). Disaggregate economic indicators as independent variables produced large Adjusted R^2 values. Lag effects between economic change and retention rate were examined. Variables in the regression model changed as lag time was varied between zero and twelve months.

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AN EXAMINATION OF THE EFFECTS OF
ECONOMIC CONDITIONS ON PILOT RETENTION

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degrees of Master of Science in Systems Management

By

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September 1982

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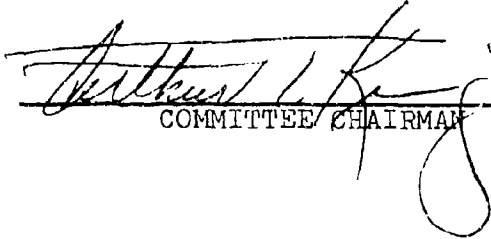

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Chapter 1

PURPOSE AND METHODOLOGY

Introduction

Pilot retention is a recurring problem in the Air Force (15:12). Currently, pilot retention, as well as, overall Air Force retention is good in light of the depressed state of the economy and the present administration's efforts to bolster the nation's defenses. Yet, the fact that massive pilot retention problems periodically arise causes concern for policy makers. Given the uncertainty of the international military atmosphere, the effects of a mass exodus in the rated force could prove quite detrimental.

Several studies (1;2;10;12) have been conducted in recent years by and for different Air Force agencies investigating this problem of retention in relation to various economic factors. The basis for these studies is the application of utility theory with respect to individual career decisions, and the results have offered promising evidence for explaining and, possibly, predicting retention based on a set of economic variables, such as, GNP, unemployment rate, consumer price index (CPI), etc. (12). One (12) of the proposed models in the studies has combined economic variables with other subjective measures to account for the effects of peculiarities and benefits characteristic of

military life. Yet, subjectivity causes complexity and possible bias in analyzing data and interpreting results.

Presently, retention enhancement studies are indirectly accomplished through costly surveys, such as the Air Force Quality of Life Survey. Theoretically, problem areas are identified and remedied, to a greater or lesser extent, resulting in a more satisfied individual and, hopefully, one who would choose to remain in the service. However, the organizational layout and sheer size of the force have proven this method of data collection to be both time-consuming and expensive (17:134-5). In the short run, because of the time lag associated with surveys, their use is limited as an effective predictive tool.

In adopting the idea of the "economic man," the researchers assume the pilot to be an individual whose behavior is primarily shaped, both directly and indirectly, by various economic influences in the environment. The factors directly affecting individual decisions are communicated through the mass media as well as other formal and informal channels. The consumer price index and unemployment rate are examples of this type factor which tend to be more widely publicized than other economic indexes. The factors are thought to be

more reflective of the true state of the economy (18). The primary twenty-two composite indexes (12 leading series, 4 coincident series, and 6 lagging series) comprise this group of factors. The researchers assume that individual perceptions of economic well-being are based on the more publicized, "direct effect" factors. These factors in conjunction with those reflecting actual economic conditions drive decisions of the economic man. The reasons for attrition are varied; however, the perception of "economic equity" has been repeatedly shown to be a dominant factor in personal decisions to leave the Air Force (2;3;5;8;10). Although, non-economic factors may be relevant in a micro-sense, on a macro level, these factors tend to play a lesser role in shaping behavior (11:118). Katona (11:118) identified a strong positive relationship between economic attitudes and behavior at the aggregate level. Further, Katona (11:118) showed that overall behavioral prediction improved with data stripped of individual attitudes.

Purpose

The purpose of this research effort is to develop a multiple regression model to be used in the description of pilot retention rates. Such a model would be objective and generalizeable due to the nature of the independent variables.

Besides resulting in ease of administration, the model would also be time-saving and cost effective, and thus, beneficial to the Air Force.

Problem Statement

Massive periodic losses of Air Force pilots have proven extremely costly in dollars as well as experience. Limited studies have shown economic factors to have a significant impact on retention. A model based on objective economic variables is needed to understand which factors influence Air Force pilot retention.

Objectives of the Research Effort

The overall objective of this research effort will be to build a model of pilot retention based on specific economic conditions.

Specific subobjectives will be:

- 1) Determine the most important economic variables which affect pilot retention.
- 2) Determine the predictive potential of the model.
- 3) Investigate the significance of airline hiring on pilot retention.

Methodology

Initially, the researchers will perform a factor analysis of selected composite economic indicators and other economic variables. (The basis for variable selection is presented in Chapter 2.) The accomplishments of this analysis allow for an investigation of underlying dimensions in the chosen manifestation variables. The analysis should result in a group of factors, smaller in number than the original variable list but capturing most of the information contained in the variables.

Because of the lag between a pilot's decision to leave the Air Force and actual departure, the researchers hypothesize that present economic conditions will affect retention rate at a future time. Typically, this lag is about six months since personnel policy requires that much notice for an officer to separate from the Air Force. To investigate the effects of this lag time, three stepwise multiple regression analyses will be performed with pilot retention as the criterion variable and factors from the factor analysis as predictor variables. The regressions will differ in that the first presumes a simultaneous impact of economic variables on retention, the second presumes a six-month lag, and the third a one year lag.

By considering the contribution of each predictor variable in the presence of other predictor variables in the model, the stepwise multiple regression allows the independent variable to be screened and eliminates those predictors which do not make a significant contribution to the explanatory power of the model. The net result of the multiple regression analyses will be a description of changes in retention rate with changes in predictor variables. A regression model based on the factors from the factor analysis can be stated as:

$$RR = b_1F_1 + b_2F_2 + \dots + b_nf_n$$

where RR is pilot retention rate,
 F_n is the nth factor of the factor analysis,
and b_n is the nth regression coefficient.

Once a regression model is built, the coefficients of each predictor variable can be standardized to show the relative magnitude of its contribution. Since predictor variables are not measured on the same scale, the standardized coefficients can be used to show if one or two predictor variables are dominant in explaining the variation in the retention rate. Even though other variables may be statistically significant, these predictors may contribute little relative to those variables which dominate the relationship.

While the factor analysis serves to delineate variable groups, this grouping might mask information unique to a single

variable. Because of this possibility of "hidden information", the researchers will perform three additional regression analyses with the individual economic variables. Similar to the previous regression with the factors, these analyses will differ in the incorporation of lag time, i.e. coincident, six-month lag, and one year lag.

Chapter 2

THE RELATIONSHIP BETWEEN PILOT LOSSES AND THE ECONOMY

Cost and Effects of Pilot Losses

Pilots are among the Air Force's most valuable resources. "Pilot losses cost the Air Force in terms of reduced experience levels, loss of training investment and, most important, loss of pilot resources needed to meet future Air Force requirements [6:1]." A further consequence of pilot losses is an increased strain on the logistics system of Air Training Command (ATC) as more students are pumped through Undergraduate Pilot Training (UPT) to replace the losses. For these reasons, the possibility of a period of high pilot attrition causes extreme concern, and as a result, Air Force Military Personnel Center (MPC) closely monitors these losses. Furthermore, MPC has gone beyond merely searching for an explanation of retention, and has proposed predicting retention based on economic conditions. Each year, losses will be incurred. These losses are replaced by new pilot accessions through Undergraduate Pilot Training. Military Personnel Center plans for such replacement and ATC budgets the necessary funds and resources for training. Some idea of what pilot attrition will be for a given period would facilitate the planning and

budgeting processes.

The replacement costs associated with pilot losses are of major significance. The Air Force suffers both a monetary loss and an experience loss. In the dollar-sense, these costs warrant special attention because they are quite high (1:7,25). Yet, quantifying the value of a pilot in dollars is difficult because of the variety of weapons systems in the AF inventory. The Air Force philosophy of the "whole man" concept further complicates this quantification since pilots are expected to leave the cockpit for a few years of crosstraining. The whole-man concept is the Air Force's attempt to career-broaden each rated officer by having rated officers perform various non-rated duties for a specified time period. Bonnell and Hendrick (2:18) contended that this whole man idea has implications for retention. Due to career-broadening tours, MPC requires three pilots to fill a single flying position over a 20 year period (1:26).

Given the idiosyncrasies of the flying job, a dollar figure in the "ballpark" helps put the impact of pilot losses in perspective. It is said to cost the Air Force approximately \$200,000 to put a pilot through UPT, the common starting point for most AF pilots (1:4;15:45). However, graduation from UPT is only the beginning, since other requirements must be satisfied

before a pilot is operationally ready to perform a mission. Besides survival training and relocation, specific operational training and in-unit qualification training must be accomplished as well. The latter costs will vary depending on the weapon system required. Bendick and Jones (1:58-60) showed the costs for this follow-on training for different aircraft to be approximately:

FOLLOW-ON TRAINING COSTS	
(Approximate)	
Aircraft	Costs
T-38	89,000
C-141	180,000
B-52H	300,000
F-15	1,100,000

Another cost, unquantifiable but very real, is the experience lost with each departure. There is a requirement for a certain level of experience among the pilots who fly a weapon system. Roth (15:43) stated that most operational units require between 30 and 50 percent of their pilots to be "experienced" in order for that unit to be operationally ready. The proper experience mix in a flying unit can enhance learning and organizational effectiveness. The benefits of experience can be transferred to younger pilots through training, testing,

and other formal channels, or through informal means, i.e. informal discussions, "hangar flying," etc. Lower experience levels may result in a less effective force with a higher accident potential, and this combination results in a lower state of combat readiness. Although combat readiness is difficult to quantify, AF leaders generally agree that it is hampered during periods of heavy pilot losses (14:6).

As previously stated, the logistics system of UPT is strained during unexpected heavy pilot loss periods. Each UPT base can comfortably handle a given number of student pilots with some ability to surge. The conclusion of the Vietnam conflict prompted the Air Force to reduce the number of UPT entrants. Coupled with massive pilot losses in 1977 and 1978, this action caused an extreme pilot shortage, and, as a result, the Air Force proceeded to increase the number of UPT students to make up for the losses. Increased UPT flying caused increased maintenance costs due to faster sortie turnaround of airframes. Routine in-hanger maintenance is sometimes required around the clock on overtime. Spare parts are used up quickly, and often, aircraft are grounded for lack of parts causing other airframes to have to pick up the load. An obvious result of these surges has been a shortening of the airframe lives of both the T-37 and T-38 aircraft. "T-38 in-

sufficiency" has become a major concern of ATC as the fleet continues to age. Plans for a replacement aircraft for the T-37 are complete, and ATC is currently planning for replacing the T-38 in the near future.

Reasons for Pilot Losses

The adverse effects of heavy pilot losses necessitate an understanding of why and when such losses occur. Kleinman and Zuhoski (12:9) developed a regression model of attrition behavior to investigate the effects of differences between military and commercial airline pay and changes in airline employment on Navy pilot retention. The authors showed that the level of airline hiring was highly correlated with pilot retention (12:B-5). In addition, pilot retention was shown to be responsive to the difference between military and commercial pilot pay (12:vii). Although the study showed the effect of airlines to be significant, no mention was made of the exact cause-and-effect relationship. Did increased airline hiring cause increased pilot losses, or did some third factor influence both airline employment and pilot attrition? Whatever the relationship, the role of commercial airlines as a potential drain on armed forces pilots is of concern (4:3;15:12,62). Projections (4:3) for airline losses due to

retirement and other miscellaneous reasons over the next five years with and without growth in the industry are presented in the following table:

TABLE 1		
Projected Airline Losses		
YEAR	NO GROWTH	GROWTH
1983	1146	1204
1984	1167	1236
1985	1030	1106
1986	809	892
1987	5013	5390

Roth (15:16-7) modeled pilot career decisions based on economic factors and various other considerations, e.g. marital status, number of children, source of commission, etc. The author's justification for using economic variables stems from the argument that utility maximization is the primary motivator in career decisions (15:16). Although this model offered an interesting look at career intent prediction on an individual basis, the detailed variables used in the model limit its use as a descriptor of population trends.

The previous studies reflect the significance of the

effect of economic variables on pilot retention, and money has been consistently cited as a "dissatisfier" in several AF surveys (3:3;5:3;8;8:13).¹ Further, according to Schuman (16) comparisons of pilot retention with individual economic factors have produced encouraging results. Economic variables then can be viewed as a significant determinant of behavior. Given the validity of the economic man assumption which is a corollary of the principle of utility maximization, the current researchers advocate a comparison of pilot retention with economic variables in an attempt to explain why large periodic losses occur and when they are likely to occur. In addressing the reason for pilot attrition, the analysts contend that economic reasons are dominant. While specific individual decisions may derive from various reasons, economic and non-economic, an attempt to model retention from such a microscopic level may not be indicative of the movement of the population as a whole (11:118).

Economic Basis for Pilot Retention

Bendick and Jones (1) advocated a dual track which was believed to have implications for improved retention; yet,

¹Money as a dissatisfier refers to the perception of low pay as a source of dissatisfaction to an individual.

pilot attrition results from more than job dissatisfaction as evidenced by recent studies and surveys. Kleinman and Zuhoski (12) contended that pilot attrition was solely dependent on airline hiring and perceived pay differences; however, this model failed to consider other reasons besides airline hiring for periods of retention difficulty. Roth (15) felt the pilot to be a utility maximizer whose decision making process was characterized by various macro and micro variables. Yet, inclusion of these micro variables restricted the useability of the model in describing overall population trends. In contrast, the present researchers consider the pilot's behavior to be dominated by his own economic perceptions, with the actual economic environment also exerting influence. Based on the above reasoning, the study attempts to determine which economic variables among selected indexes best correlate with pilot retention.

A majority of the economic indicators employed in this analysis were obtained from the Business Conditions Digest (BCD), a monthly report by the Bureau of Economic Analysis. BCD publishes over 300 economic time series which are particularly useful to business analysts and forecasters in describing the present state of the economy and predicting the economic future. Each series is derived by computing three

separate timing scores for peaks, troughs, and all turns. Then, the series are classified as either leading, coincident, or lagging at peaks, troughs, and all turns according to the type of timing that maximize their scores. The leading series tend to lead at business cycle turns; the coincident series roughly coincide at the turns; and the lagging series tend to lag at business cycle turns. Those indicators exhibiting regularity in a series are classified as cyclical. In the case where timing at a given turn is erratic, the series is said to be unclassified. Presently, business analysts and forecasters rely on twenty-two composite indexes of leading, coincident, and lagging indicators for interpreting current and predicting near-future business conditions. These twenty-two indexes are thought to best reflect actual economic conditions and their direction. Because of the previously mentioned direct and indirect economic influences affecting pilot decision-making, the researchers chose both specific composite indexes to represent the actual economic environment and various other economic indicators which were believed most likely to have an effect on individual behavior.

The researchers selected the following economic indicators for examination in this research effort. Those indicators representing a leading, coincident, or lagging series

are identified as such; otherwise, the indicator is unclassified.

Consumer Price Index (CPI) F2². The CPI measures the change in prices of a fixed market basket of goods and services purchased by urban wage earners and clerical workers--both families and single persons. In a more general sense, the series measures the change in prices of everyday purchases.

White Collar Unemployment Rate-F3. This rate, based on survey data, is a monthly estimate of the number of white collar workers who are unemployed. An unemployed person is one who did not work during the survey week, who made specific efforts to find a job within the past four weeks, and who was available for work during the survey week. The researchers chose white collar unemployment because it is more representative of the pilot population being studied.

Average Percent Change in GNP (Coincident)-F4. GNP is the most comprehensive single measure of aggregate economic output. This indicator represents the market value of the total output of goods and services produced by the nation's economy before de-

²This alphanumeric representation designates the actual variable symbols used in the analysis.

duction of depreciation charges and other business allowances. This series measures the percent change in GNP from quarter to quarter.

Lag of Real Military Pay with respect to CPI-F5. This measure compares changes in average real military pay with changes in the CPI. This difference serves to represent the change in spending power of AF pilots.

Change in Disposable Income-F6. Disposable personal income is equal to personal income less personal tax and nontax payments to general government. Thus, this income represents the spending or saving power of an individual.

Average Prime Rate (Lagging)-F7. This series reflects the interest rate that banks charge their most credit-worthy business customers on short-term loans.

Personal Saving Rate-F8. Personal saving measures the current saving of individuals and is equal to the excess of disposable income over personal outlays. This rate measures the proportion of disposable personal income that has been saved.

Index of Private Housing Units (Leading)-F9. This series measures the month-to-month changes in the number of housing units authorized by local permit-issuing agencies. The data relates to the

issuance of permits and not to the actual start of construction.

Airline Hiring-F10. These figures represent both pilots recalled from furlough status and new hires for major air carriers on an annual basis.

Value of Manufacturer's New Orders for Consumer Goods and Materials (Leading)-F11. This series measures new orders for durable goods (excluding capital goods and defense products) and for nondurable goods industries which have unfilled orders. A new order is a communication of an intention to buy for immediate or future delivery. An unfilled order is one received but not yet passed through the sales account.

Vendor Performance, Percent of Companies Reporting Slower Delivers (Leading)-F12. This series shows the percentage of Greater Chicago Area purchasing agents who are experiencing slower deliveries in the current month compared with previous month. The volume of business being handled by the suppliers of these firms is reflected in the series, with slower deliveries indicating a higher volume of business.

Net Change in Inventories on Hand and on Order (Leading)-F13. This series measures the monthly change in manufacturing and trade inventories and manufacturers' unfilled orders, ex-

cluding unfilled orders for capital goods and defense products. Increases in inventories on hand and on order would tend to indicate a coming upswing in the business cycle.

Change in Total Liquid Assets (Leading)-F14. This indicator consists of all holdings of liquid assets by the private domestic nonfinancial sector. Liquid assets include the following: currency, demand deposits, time deposits at commercial banks and non-bank thrift institutions, savings bonds, negotiable certificates of deposits, short-term marketable U.S. securities, open market paper, federal funds and repurchasing agreements, and money market fund shares. This indicator is actually a money supply measure for the private sector of the economy.

Manufacturing and Trade Sales (Coincident)-F15. This indicator represents the inventories or sales of manufacturing, retail, and merchant wholesalers' establishments.

Ratio, Consumer Installment Debt to Personal Income (Lagging)-F16. This ratio measures the amount of consumer installment debt outstanding per dollar of personal income. Installment credit includes all consumer credit held by financial intermediaries and retail outlets that is scheduled to be repaid in more than one installment. A high ratio would be indicative of a recent upswing in the business cycle.

Personal Income, Less Transfer Payments (Coincident)-Fl7. This series measures the constant-dollar personal income received by individuals, unincorporated business, and nonprofit institutions excluding transfer payments. Transfer payments consist of income received by persons for which no services are currently rendered - both in government and in business. These payments are excluded because they contain large countercyclical elements, such as unemployment compensation, which tend to decrease the cyclical conformity of the series.

For consistency, the researchers chose to represent all dollar amounts in 1972 dollars. Because of a lack of more detailed retention data in earlier years, all variables were transformed to semiannual data. For most variables in the analysis, this limitation posed no problem since these variables were recorded quarterly, and simple addition or averaging was all that was required to represent the data on semi-annual basis. The airline hiring figures were only available in yearly amounts which necessitated an assumption of a uniform distribution of hiring over each year. This assumption allowed for the calculation of a six-month average for airline hires. (Semiannual conversions for all variables in the analysis are presented in Appendix B.)

Chapter 3

RESULTS

Data analysis was performed in three steps. First, a factor analysis was used to group the 16 independent variables into a smaller number of constructs or factors. Second, the researchers performed a stepwise multiple regression of the factors from step one with retention rate as the dependent variable. This second step allowed for a description of retention rate based on aggregate economic factors. Third, a stepwise multiple regression of the 16 economic variables with retention rate was performed. This third step allowed for an explanation of retention based directly on the independent variables. (The 16 independent variables were described in Chapter 2.)

Factor Analysis

Given the nature of the selected economic variables, it is reasonable to assume the existence of broader underlying factors which capture most of the information contained in the 16 variables. If that is the case, then these factors may form a useful description of pilot retention.

The researchers performed principal component analysis, a statistical procedure which reveals constructs underlying a

larger group of variables. Factor analysis of the 16 independent variables with varimax rotation yielded four orthogonal (un-related) factors. The loading of the variables on each of the four factors are presented in Table 2.

The factor loadings in each row show each variable's contribution to the four underlying factors. Conversely, since more variables load significantly on a single factor, the variables can be used to describe the more general factors. For example, factor 1 is approximately equal to the sum of the significant factor loadings times their respective variables or:

$$\begin{aligned} \text{Factor 1} = & .825(\text{F5}) + .617(\text{F7}) - .800(\text{F8}) + .713(\text{F10}) + .947(\text{F15}) \\ & + .822(\text{F16}) \end{aligned}$$

Table 2				
Factor Analysis				
	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
F2	.49395	.30126	-.69692	-.08213
F3	-.23573	-.77419	.53304	-.02216
F4	.00620	.19788	.93364	.04358
F5	.82465	-.12146	-.16903	-.10929
F6	.07021	-.24859	.57698	.69333
F7	.61723	-.23580	-.34216	-.47052
F8	-.80014	.3876	.46917	.13638
F9	.06175	.76542	.38364	.38924
F10	.71280	.44553	.16038	.39304
F11	.55413	.77913	.17548	.12590
F12	-.12272	.95681	-.06574	.09101
F13	-.11246	.27266	-.00881	.89719
F14	.16934	.71124	.50710	-.07875
F15	.94725	.23923	.09989	-.08750
F16	.82220	.35922	-.29266	.18374
F17	.08710	.20178	.92019	.24432

Examining the composition of each of the factors, the researchers can provide descriptive names for each. In this instance, factor 1 is primarily composed of lagging economic indicators and will be referred to as the Lagging factor. By the same logic, factor 2 is the Leading factor, and factor 3 is the Coincident factor. Factor 4 is composed of only two variables, F6, Change in Personal Disposable Income, and F13, Net Change in Manufacturing and Trade Inventories. The researchers chose not to name this factor as a descriptive term was not readily apparent.

Explanation of Multiple Regression Procedure

Multiple regression is a statistical procedure which can be applied to analyze the relation between a dependent variable and a set of independent variables. Multiple regression is based on plotting a "best fit" regression line to a set of data points using the method of least squares. This technique may be used in a variety of situations to draw descriptions or make inferences.

In the present study, multiple regression is used as a descriptive tool to find the best linear prediction equation of retention rate from a variety of economic data. The researchers used the Statistical Package for the Social Sciences (SPSS) , an

integrated system of computer programs, to perform stepwise multiple regression. This stepwise regression method considers each independent variable and selects the most significant to enter the regression equation. The stepwise algorithm then considers all independent variables previously brought into the equation and discards any which may have lost significance in the presence of the new variable. Stepwise multiple regression continues in this fashion, adding the most significant independent variable to the regression equation, then reexamining the variables in the equation for significance. The significance test used is the two-tailed F-test of each variable's regression coefficient. The null hypothesis is that the regression coefficient of the variable is zero, and the alternate hypothesis is that the regression coefficient is not zero. In statistical notation,

$$H_0: \beta = 0$$

$$\beta \neq 0$$

where β is the regression coefficient. A highly significant regression coefficient is indicated by a small area in the tail of the F probability distribution function. The area in the tail is denoted by the variable α . If, for example, a particular variable has an α value of .1, then it is said to be significant at the .1 level. In other words, the probability

that the dependent variable and independent variable are only related by chance is 10 percent.

In a similar fashion, SPSS stepwise multiple regression performs an overall F-test of the entire regression equation based on the hypothesis that all regression coefficients are zero and the alternate hypothesis that at least one coefficient is not zero. In statistical notation this is:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_j = 0$$

$$H_a: \beta_j \neq 0$$

where β_j is the regression coefficient of the j th independent variable. These built-in tests for significance give the researcher high assurance of not making a type 1 error, that is, rejecting the null hypothesis when it is true.

The stepwise multiple regression has an important advantage over simple multiple regression in that each independent variable must make a significant contribution in the presence of all other variables in the model, or it is eliminated from the regression equation. This procedure eliminates difficulties caused by multicollinearity which refers to the situation in which certain independent variables are highly intercorrelated (13:4-65). This regression package prohibits multicollinear variables from entering the model. The following information is primary output from the stepwise regression procedure:

Adjusted Coefficient of Determination (Adjusted R^2). This value is the percentage of variance in the dependent variable explained by the regression model. It is adjusted for the number of variables in the model. Without adjustment, R^2 ultimately equals 1.0 (perfect prediction) merely by adding numerous variables to the model.

Beta Weight (B). This value is the standardized regression coefficient. The relative magnitude (absolute value) of beta weights indicates which individual independent variables are contributing most to the model, i.e., explaining the variation in the dependent variable. Beta weights are useful since data are often measured on different interval scales with no direct means of comparison.

Regression Coefficient (β). This value is the coefficient by which an independent variable is multiplied to obtain the predicted value of the dependent variable. Each independent variable has its own β value, so the regression equation appears as:

$$\text{dependent variable} = C + \beta_j F_j + e$$

where C is a constant, F_j is the j th independent variable, and e is the error term.

Regression Analysis of Four Factors with Retention Rate

Regression with Retention Rates Unlagged. The four factors derived in the factor analysis were regressed with retention rate. The results of this analysis are summarized in Table 3.

TABLE 3	
Regression of Unlagged Retention Rates with Factors	
Regression Equation	
$RR = 1.156 - .0009 \text{ (Leading factor)} + .005 \text{ (Coincident factor)}$	
Adjusted $R^2 = .298$	
Beta Weights	
Leading factor	.592
Coincident factor	.428
F/Significance	4.406/.003

The adjusted R^2 value indicates that the Leading and Coincident factors account for 29.8 percent of the variation in retention rate. The beta weights are roughly equal indicating that the factors make about equal contributions toward a description of retention rate.

Regression with Retention Rates Lagged 6 Months. With retention rates lagged by six months, the four factors were again used in

a stepwise multiple regression. The results are shown in Table 4.

TABLE 4	
Regression of 6-Month Lagged Retention Rates with Factors	
Regression Equation	
$RR = 1.121 - .00084 \text{ (Leading factor)} + .0037 \text{ (Co-incident factor)}$	
Adjusted $R^2 = .344$	
Beta Weights	
Leading factor	.637
Coincident factor	.429
F/Significance	4.933/.025

With a six month lag in retention values, the Leading and Coincident factors account for 34.4 percent of the variation in the observed values of retention rate.

Regression with Retention Rates Lagged 1 Year. As a third step, retention values were lagged by twelve months. This lagging allowed for examining the effect of economic conditions at a given time on retention one year later. Regression of the four factors used previously with a twelve month lagged retention rate provided the information presented in Table 5.

TABLE 5	
Regression of 1 Year Lagged Retention Rates with Factors	
Regression Equation	
$RR = 1.168 - .00097 \text{ (Leading factor)} + .00185 \text{ (factor 4)} + .0025 \text{ (Coincident factor)} + .00005 \text{ (Lagging factor)}$	
Adjusted $R^2 = .505$	
Beta Weights	
Leading factor	.827
Factor 4	.564
Lagging factor	.327
F/Significance	4.572/.023

With the year lag in retention figures, the four factors taken together accounted for about half of the variance in retention rate. The large beta weight for the Leading factor indicates that it contributes significantly more to the prediction than the other three factors. In fact, the Leading factor alone accounts for 35 percent ($\text{Adj. } R^2 = .35$) of the variation in retention.

Regression Analysis of Economic Indicators with Retention Rate

The researchers performed another set of regression analyses using the 16 economic indicators described in Chapter 2

as independent variables. By performing these regressions with the individual variables, the analysts were able to investigate the direct impact of these variables on retention rather than an "indirect" effect through an intervening factor.

Regression with Retention Rates Unlagged. Stepwise regression of the 16 variables with retention rates from the same time period produced the information shown in Table 6.

TABLE 6	
Regression of Unlagged Retention Rates with 16 Variables	
Regression Equation	
$RR = -1.644 - .0009 (F9) + .17689 (F3) + .01949 (F15) - .00248 (F6) - .00409 (F5) + .02871 (F8)$	
Adjusted $R^2 = 1.0$	
Beta Weights	
F9	.033
F3	1.306
F15	1.418
F6	.414
F5	.283
F8	.385
F/Significance	R/O

This R^2 value in this table indicates that six variables account for 100 percent of the variation in retention rate. This is a surprising result and the implications will be discussed

further in Chapter 4. There is a possibility that these results are a statistical anomaly rather than significant discovery. The beta weights of F3, White Collar Unemployment Rate, and F15, Manufacturing and Trade Sales, show these variables to be much more important in the retention rate prediction than the other four variables in the equation.

As a next step, the researchers chose to restrict the entering variables by limiting entry to those variables with a contribution of .1 or greater to R^2 . Table 7 shows the results of the stepwise regression of the 16 variables with unlagged retention values.

TABLE 7	
Regression of Unlagged Retention Rates with Entry Restrictions for 16 Variables	
Regression Equation	
$RR = 1.114 - .0529 (F8) - .0011 (F9) + .0494 (F3)$	
Adjusted $R^2 = .857$	
Beta Weights	
F8	.709
F9	.412
F3	.365
F/Significance	28.945/.000

The adjusted coefficient of determination shown in this table indicates that 85.7 percent of the variation in retention rate

is explained by only three variables. The three additional variables in Table 6 add only 14.3 percent. The regression equation in Table 7 yeilds a good description of retention rate without using variables which only marginally improve R^2 .

Regression with Retention Rates Lagged 6 Months. After lagging retention rates six months, the researchers performed another stepwise multiple regression with the sixteen economic variables. The results of this regression are shown in Table 8.

TABLE 8	
Regression of 6-Month Lagged Retention Rates with 16 Variables	
Regression Equation	
$RR = 1.173 - .00227 (F12) - .029 (F8)$	
Adjusted $R^2 = .700$	
Beta Weights	
F12	.624
F8	.506
F/Significance	17.355/.0

Vendor Performance (F12) and Personal Savings (F8) accounted for 70 percent of the variation in retention rate. The beta weights reveal that both variables make roughly equal contributions in describing retention.

Regression with Retention Rates Lagged 1 Year. Regression analysis of the 16 variables with retention rates lagged one year produced the information displayed in Table 9.

TABLE 9	
Regression of 1 Year Lagged Retention Rates with the 16 Variables	
Regression Equation	
$RR = .919 - .00361 (F13) - .00096 (F12) + .00299 (F15) + .00117 (F6)$	
Adjusted $R^2 = .779$	
Beta Weights	
F13	.734
F12	.293
F15	.294
F6	.278
F/Significance	15.809/.002

In this instance, the regression equation explained 77.9 percent of all of the variation in retention rate. Examination of the beta weights showed F13, Net Change in Inventories, to be the major contributor in accounting for this variation.

Analysis of Residuals

A residual is the difference between an observed value of the dependent variable and a predicted value of the dependent variable. In other words, residuals are measures of the error

component in the regression equation.

In the regression analysis, the error components are assumed to be independent, have a mean of zero, and have constant variance throughout the range of the dependent variable. Violation of these underlying assumptions may invalidate the summary statistics shown in Tables 3 through 9. A direct examination of residuals allows for verification of the assumptions. This technique consists of plotting the residuals against another meaningful dimension, time, in this case, and searching for visible patterns. A random scatter about the mean supports the validity of the assumption.

Figure 1 is a scatterplot of the residuals corresponding to Table 7.

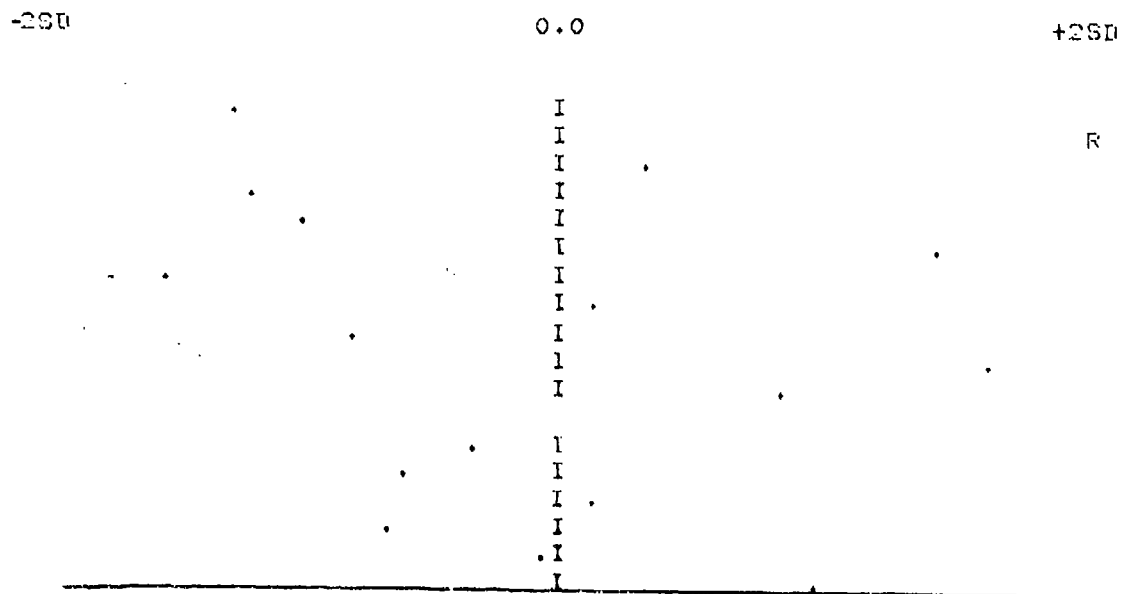


Figure 1

Residuals Plot for Regression of Unlagged Retention Rates with Variables (Table 7)

The vertical axis represents time and the horizontal axis represents residuals measured from -2 to +2 standard deviations. This scatterplot shows that the residuals are fairly well scattered about the mean indicating that the underlying assumptions appear justified. Figure 1 is typical of the scatterplots for the regression analyses corresponding to Tables 3 through 9.

Summary

Six multiple regression analyses were performed. The best results from a description/prediction standpoint occurred when the 16 economic variables were used as independent variables rather than combined into factors. All lagged regressions with the economic variables resulted in relatively high values of adjusted R^2 . Interpretations and the significance of these findings are discussed in Chapter 4.

Chapter 4

INTERPRETATION OF RESULTS

In this chapter, the researchers analyze the results of the study. Comments are offered in the same order as the results were listed in Chapter 3, that is, starting with the factor analysis and progressing through the six multiple regression analyses.

Factor Analysis

The 16 economic variables were condensed into four factors by using principle component analysis. It is interesting to note that most variables loaded significantly on a single factor. Statistically, this was an ideal situation since it allowed a straightforward mathematical description of the factors and offered the best chance to associate meaningful names with the factors. By noting which variables loaded on each factor, the researchers named the first three factors, the Lagging factor, the Leading factor, and the Coincident factor, respectively, according to the classification of its component variables. The mathematical description of each factor was listed in Chapter 3. Again, because most variables loaded significantly on one factor, the factors were rather well de-

fined mathematically. Using the four factors in a regression analysis afforded a good opportunity to build a model which provides a description of retention.

Regression Analysis of Four Factors with Retention Rate

Regression with Retention Rates Unlagged and Lagged 6 Months.

Regression of the four factors with coincident retention values and six-month lagged retention values produced low adjusted coefficients of determination (R^2). Only the Leading factor and the Coincident factor entered the regression equation for both regression analyses. The resulting R^2 values were .298 and .344 respectively; therefore, the best of these regression equations accounts for only 34.4 percent of the variation in retention rate. Since over 60 percent of the variation in retention rate was unexplained, the researchers felt further refinement of these two regression models would not be fruitful.

Regression with Retention Rates Lagged One Year. Regression analysis of the four factors with the retention rate lagged one year produced a regression equation with all four factors. The adjusted coefficient of determination for this equation was .505, or just over 50 percent of the variation in retention rate was explained.

Because all four factors were in the model, and the four factors were comprised of 16 variables, the time required to gather and process the data was considerable. This is an inefficient model. Furthermore, the likelihood exists for a lot of "noise" or spurious information in such a complex model.

Regression Analysis of Economic Indicators with Retention Rate

Regression with Retention Rates Unlagged. Regression analysis of unlagged retention rate with the economic variables produced a surprising adjusted R^2 of 1.0. This was an unexpected result, since it seemed unlikely that economic factors could account for 100 percent of the variation in the retention rate. Some pilots leave the service for other than economic reasons. Separations have occurred for humanitarian reasons, personal dissatisfaction with different facets of military life, and various other non-economic reasons. A possible explanation for this rarely obtained R^2 might be that non-economic separations are few in number in comparison to economically induced separations and occur at a more or less constant rate. As a result, non-economic factors might not account for any of the variation in retention rate.

The short time span of the data (eight years) may also partially account for the high R^2 . A limited number of data

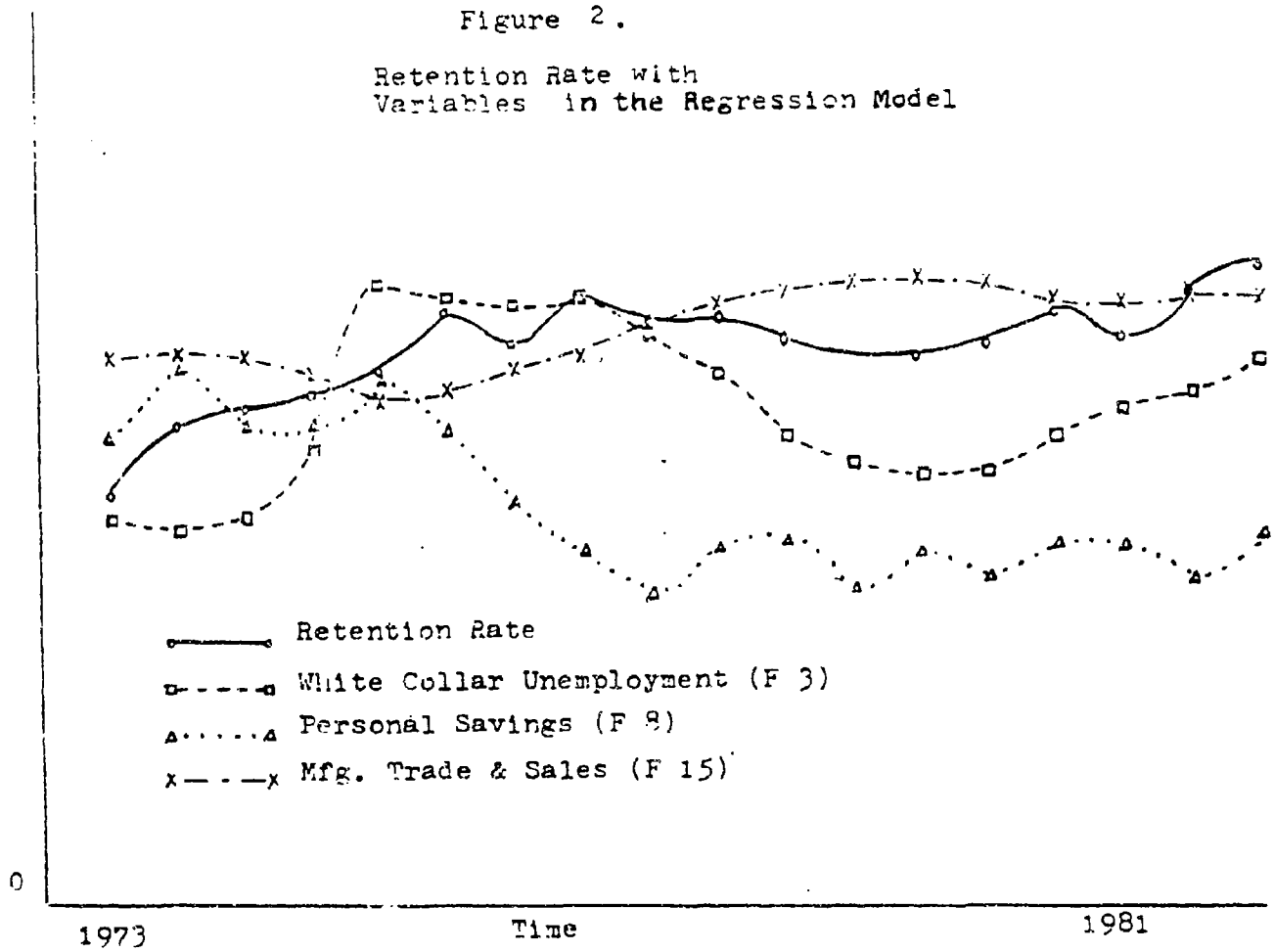
points makes it easier to fit a regression line. Still, this alone could not account for perfect correlation.

The regression equation for this perfect description was composed of six variables, each of which consisted of overlapping information as well as information unique to that variable. Apparently, each variable captured a different bit of information, and taken together the variables explained all the variation in the dependent variable.

Graphical analysis of the data offered some clue as to the reason for the high R^2 value. Figure 2 is a graph of retention rate along with the three most significant variables in the regression model versus time. To facilitate visual comparisons of trend information, the vertical axis is not an absolute scale, but shows the relative trend of each variable. The horizontal axis represents time years. As evidenced by the graphs, some of the variables matched the changes in retention rate very closely. Particularly noteworthy was the plot of White Collar Unemployment Rate (F3).

Figure 2.

Retention Rate with
Variables in the Regression Model



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The finding of a perfect description is probably the result of a combination of certain assumptions about the data (see Chapter 2 and Appendix B), the limited number of data points, and the small absolute variation in retention rate. However unreasonable this may seem, the implications for a very strong relationship between economic variables and retention rate cannot be ignored.

In quest of a more useful and, perhaps, more reliable model, the researchers chose to restrict the variables in the regression model. Only those variables which contributed .1 or more to the adjusted R^2 were allowed to enter the regression equation. The resulting model contained the following three variables: Personal Savings (F8), Housing Starts (F9), and White Collar Unemployment Rate (F3). The adjusted coefficient of determination was still a sizeable .857 which indicated a good model for describing variation in retention rate.

Recall that this regression of retention rate was performed coincident with the economic variables. This was contrary to the researchers assertion of a lag of retention rate behind economic conditions at a given time. This analysis served as an important first step in the exploration of the effects of economic conditions on retention. This particular regression gave indications that retention and the economy are

simultaneously affected by a third unknown factor. The scope of this study did not allow a search for the identity of this unknown third factor.

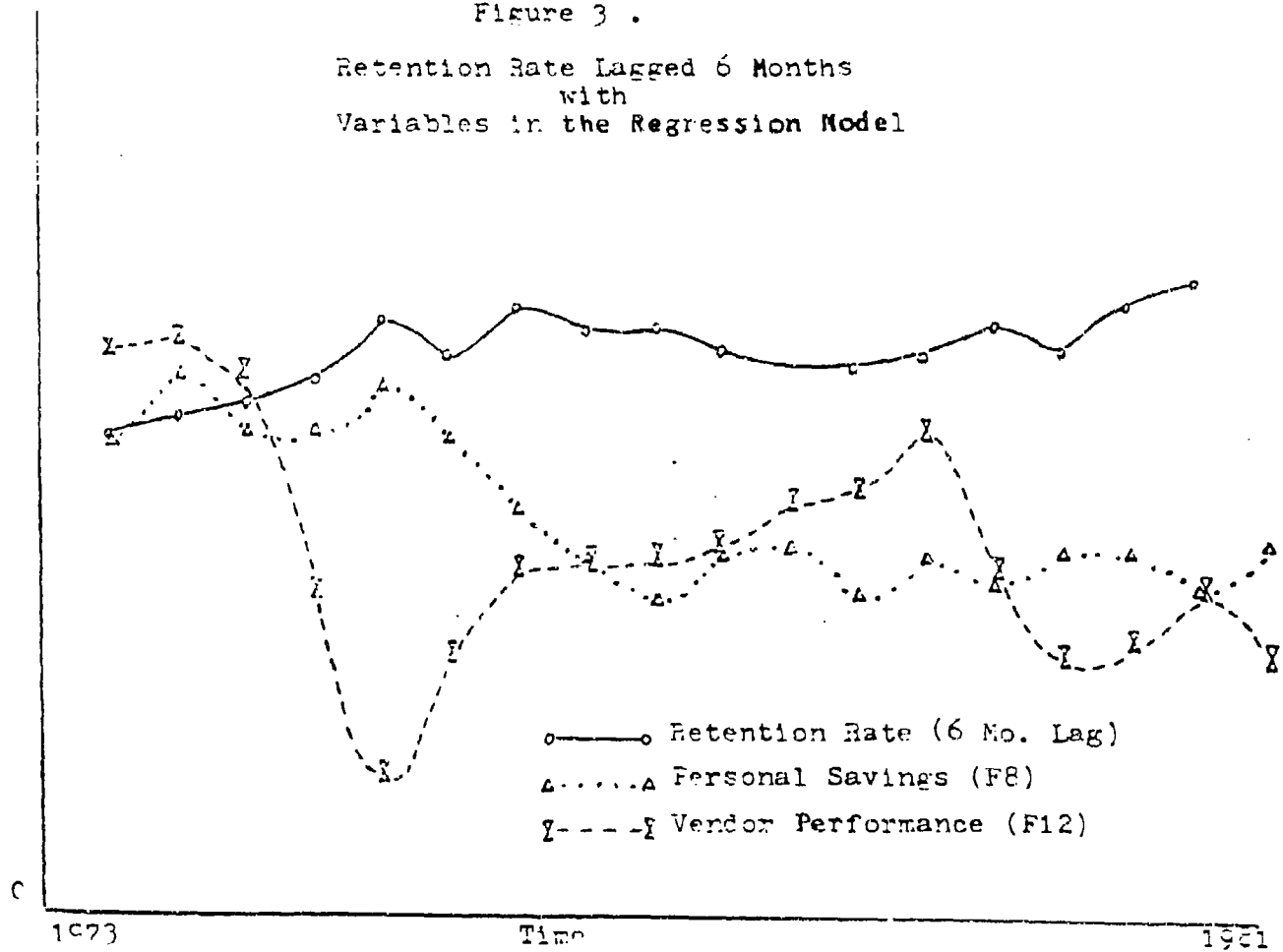
Regression with Retention Rates Lagged 6 Months. Lagging retention rate six months and performing a multiple regression provided a description of how the economic variables affected retention six months later. In this case, the stepwise regression algorithm built a model containing two variables: Vendor Performance (F12), and Personal Savings (F8). This model's adjusted R^2 of .700 was reasonably large and indicated that this simple two-variable model described 70 percent of the variation in retention rate. The resultant regression equation was the following:

$$RR = 1.17 - .227 (F12) - .295 (F8)$$

The negative sign of each coefficient in the regression equation showed that as Vendor Performance and Personal Savings increased, retention rate decreased six months later. Figure 3 (p.45) presents the variables in the model graphically.

Figure 3 .

Retention Rate Lagged 6 Months
with
Variables in the Regression Model



Although it might be intuitive that as the economy turns down retention rate will improve, this simple model quantifies that relation fairly well. It is not intuitive why Vendor Performance is the strongest contributor to the model. It would be unreasonable to contend that Vendor Performance directly affects retention rate. Regression analysis can not be used to verify such a cause and effect relationship. Rather, Vendor Performance is an aggregate measure of certain economic conditions which takes into account retail sales and other economic variables. This regression analysis showed Vendor Performance to be a good surrogate measure of lagged retention rate.

Regression with Retention Rates Lagged One Year. When retention values were lagged one year, the regression equation became slightly more complex, and the adjusted R^2 improved. The equation was the following:

$$FF = .919 - .36 (F13) - .96 (F12) + .29 (F15) + .12 (F6)$$

where: F13 is Change in Inventories on Hand

F12 is Vendor Performance

F15 is Manufacturing and Trade Sales and

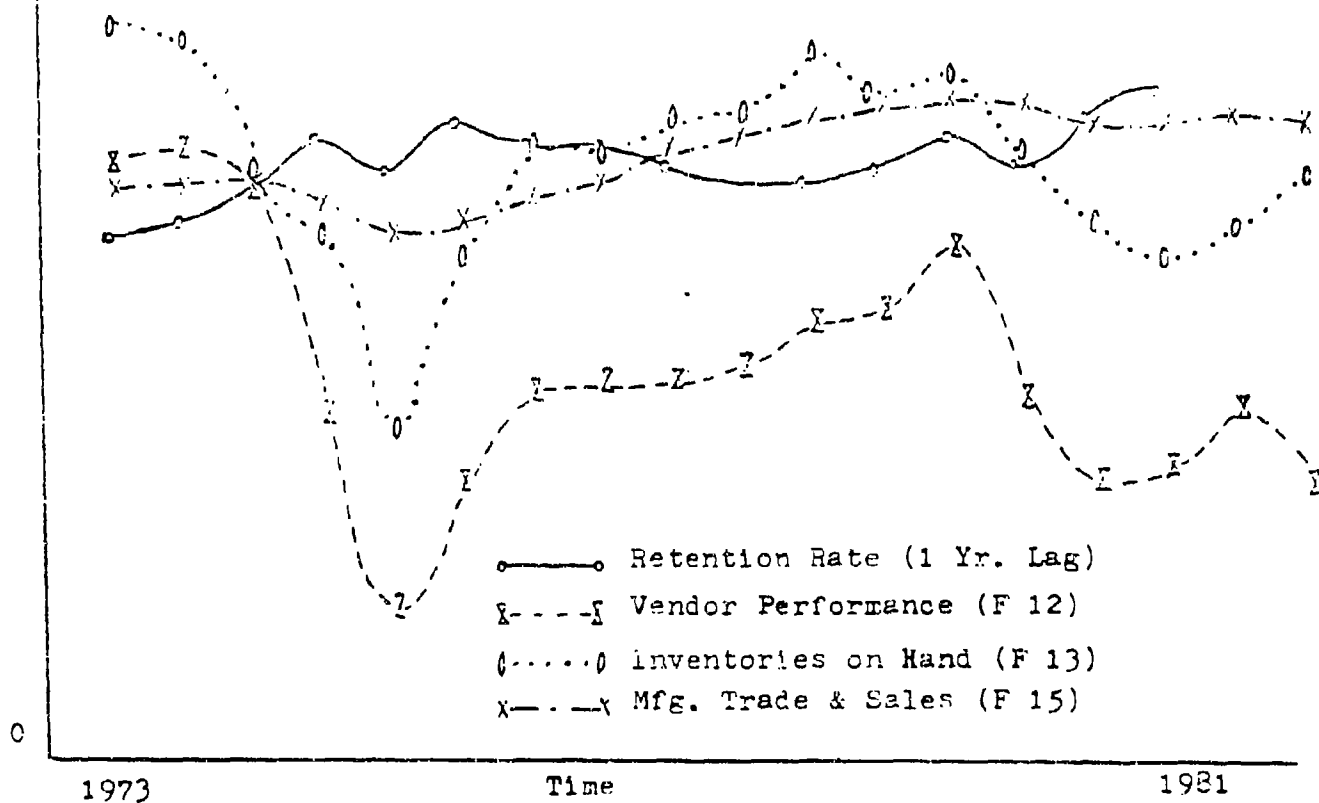
F6 is Change in Disposable Income

As in the six-month lagged regression, Vendor Performance was identified as one of the independent variables. Three new

variables were also introduced into this model. According to the regression equation, Vendor Performance and Net Change in Inventories on Hand were inversely proportional to retention rate, and Disposable Income and Income Lag were directly proportional. Figure 4 graphically presents the three most important variables in the model.

Figure 4 .

Retention Rate Lagged One Year
with
Variables in the Regression Model



The most notable distinctions in the two lagged regressions were the differences in number and type of independent variables which best described retention rate. While Vendor Performance was the only variable common to both analyses, it accounted for 45.4 percent of the variation in retention rate for the six-month lagged model as compared to 19.4 percent for the one year lagged model. These findings revealed timing to be an important consideration in determining which aspects of the economy affect retention. Logically, some variables such as income should have a direct impact on retention; however, the inclusion of variables descriptive of the economy itself seems to substantiate the researchers' contention of an indirect effect of actual economic conditions on a pilot's decision to remain in the Air Force.

Other Comments

Another surprising result was the absence of the Airline Hiring variable in any of the models. As previously mentioned, Kleinman and Zuhoski (12) offered empirical evidence for a significant positive relationship between the level of airline hiring and pilot attrition. An investigation of correlation coefficients for Airline Hires with the other variables in the analyses showed Airline Hires, F10, to be significantly cor-

related with Manufacturing and Trade Sales, F15, (.779)³, Personal Savings, F8, (-.562), Housing Starts, F9, (.557), and White Collar Unemployment Rate, F3, (-.429). The three variables, F3, F8, and F9 were present in the unlagged regression model in which the entry restriction was placed on the independent variables (Table 7). Personal Savings was also a major contributor to the six-month lagged regression (Table 8), and Manufacturing and Trade Sales, F15, was significant in the one year lagged model. Although there was not a strong correlation between Vendor Performance (F12) and Airline Hires, Vendor Performance was found to be highly correlated (-.734) with White Collar Unemployment Rate (F3). As a result of these myriad correlations, the economic variables appeared to capture the majority of information offered by the airline hiring variable.

³The number in parenthesis is the correlation coefficient, r.

Chapter 5

RECOMMENDATIONS AND CONCLUSION

The researchers have purposely hesitated to use the term "predict retention" in this study. The reason for this is sound. Since only eight years of data were available, there was not enough data to both build and validate the model in a completely convincing manner. As with most statistical research, more data could be used to refine and validate these regression models.

The high values of R^2 in some of the analyses indicated that retention rate was described very well over the time period studied. This time period included two major cycles of high and low retention. The researchers believe that the models should be validated by data for another retention cycle before using them as a reliable descriptive/predictive tools.

The regression analyses of the four factors with retention rate showed little promise since the factors were probably too complex to allow extraction of useful information. The most interesting result was the high adjusted R^2 obtained when the unlagged retention rate was regressed with the economic variables. The model with the most potential resulted from the regression of the one year lagged retention rate with the 16 economic variables. This model accounted for nearly 80

percent of the variation in retention. With sufficient validation, this model could provide retention predictions far enough in advance to have policy making applications.

Besides validation and further investigation of the proposed regression models, the researchers offer other areas for further study. One suggestion is a more thorough investigation of economic variables. In this study, variable selection was based on the researchers' belief that a specific variable was representative of a group of variables. For example, Business Conditions Digest actually publishes the data for twelve different leading indicators; however, the researchers only investigated five leading series. The five chosen were felt to be most representative of the trend information conveyed by the twelve series comprising this group.

The difference in the resultant equations for the two lagged regressions with the 16 variables revealed the significance of lag time. Given variation in the length of time between the decision to separate and the actual separation, different economic variables must be employed to accurately describe retention rate. The result of these analyses suggested the need for a more detailed examination of the effects of timing on the relationship.

The researchers have offered a good description of Air Force pilot retention based on economic variables. The results lend credence to the researchers' assertion of the pilot as an economic being who bases career decisions on various direct and indirect economic influences. Further, the obtained regression equations satisfied the requirements for a practical, generalizeable model easily employed to describe retention rate. Pilot retention varied between .63 and .98 during the time span studied. When retention approached the lower figure, the AF struggled to change the trend. Forewarning of such an occurrence would allow preventive action rather than emergency measures. The researchers believe they have offered a tool which can give a timely warning.

APPENDIX A: COMPUTATION OF RETENTION RATE

A prerequisite for calculating the rate of retention is the identification and description of the population. The sample for the study consisted of Air Force pilots with between six and eleven years of service. The rationale for selecting this subset was that pilots with less than five years are unable to get out due to the incurred commitment. Further, those pilots with twelve or more years are considered career-committed based on a twenty-year retirement program. With respect to pilot losses, a distinction must be made between voluntary and involuntary losses. Involuntary losses are more or less uncontrollable, in that Air Force officers can exit the corps for a variety of reasons, i.e., medical, disciplinary, etc. The researchers focused on the "pure losses" or voluntary losses.

Dividing the total voluntary losses by the population yields the total loss rate, TLR, and one minus TLR gives the retention rate, RR. The retention rate for year six would be RR_6 , year seven, RR_7 , and so on. To account for the different years of service, MFC employs the cumulative continuation rate, CCR, which is the product of the retention rates for given years. For the eight-year group, the CCR would be calculated as follows:

$$CCR_8 = RR_6 \times RR_7 \times RR_8$$

Given that 100 officers entered in year 6 and the current trends persist, CCR_8 relates that percentage of pilots in the initial group that would remain after year 8. Likewise, CCR_{11} would be calculated as follows:

$$CCR_{11} = RR_6 \times RR_7 \times RR_8 \times RR_9 \times RR_{10} \times RR_{11}$$

APPENDIX B: EXPLANATION OF VARIABLE CONVERSIONS

The cumulative continuation rates (CCRs) used in the analysis were obtained from the Defense Manpower Data Center located in Monterey, California. A rate was calculated for each year for the 6 to 11 year groups resulting in a total of six rates for a single time frame, i.e., CCR_6 , CCR_7 , CCR_8 , . . . CCR_{11} . The researchers selected CCR_8 to be used in the regression analysis, as this rate approximated a median value for a set of rates. Because the retention rates for 1973 through 1975 were published on a semiannual basis, the researchers elected to represent all variables in the analysis semiannually. Cumulative continuation rates after 1975 were recorded quarterly. Conversion of these data was accomplished by averaging retention rates for the first two quarters and the last two quarters for a particular fiscal year.

The following text gives a description of this biannual conversion for each of the 16 independent variables.

CPI (F2) - The series used was the Change in Index of Consumer Prices, All Items, over 6-month spans, series 320-C in Business Conditions Digest (BCD). In this case, no conversion was necessary as these data were published semiannually.

White Collar Unemployment Rate (F3) - Values for this indicator were obtained from Employment and Earnings, a publication of the Bureau of Labor Statistics. Monthly rates were listed under the table entitled, Major Unemployment Indicators, Seasonally Adjusted. Biannual rates were obtained by averaging the first six months' values for the first half of the year and the second six months' values for the last half.

Percent Change in GNP (F4) - The series used was the Percent Change in Gross National Product in 1972 Dollars, series 50c in BCD. Values for this indicator were published on a quarterly basis, so the researchers averaged the numbers. To accomplish the semiannual conversion, first and second quarter values were averaged, and the third and fourth quarter values were averaged.

Percent Lag in Income (F5) - This variable was first created by Roth (15) in his study of pilot retention. Values were computed by comparing changes in average real military pay figures including flight pay with changes in CPI. By noting differences in the two changes, a lag percentage was computed indicating a loss (gain) in spending power with respect to CPI.

Change in Disposable Income (F6) - The series used was Disposable Personal Income in 1972 Dollars, series 225 in BCD. Values were

published on a quarterly basis. To obtain values for the first half of a year, the researchers subtracted the fourth quarter number of the previous year from the second quarter value of the year in question. Similarly, for the second half of a year, the researchers subtracted the second quarter value from the fourth quarter value of the same year.

Average Prime Interest Rate (F7) - The series used was the Average Prime Rate Charged by Banks, series 109 in BCD. For this rate, values were published by quarters. Once again, simple averaging of the first and second quarters and the third and fourth quarters was accomplished to obtain two values for each year.

Personal Saving Rate (F8) - For this indicator, the researcher used the series titled, Personal Saving Rate as a Percent of Disposable Personal Income, series 293 in BCD. As these rates were published quarterly, the first and second quarter were averaged for the first half. .

Housing Starts (F9) - The series utilized was series 29 in BCD entitled, Index of New Private Housing Units Authorized by Local Building Permits. Again, numbers were published by quarters, and averaging of the first and second quarter values and third and fourth quarter values was performed.

Airline Hires (I10) - Airline pilot hiring statistics for major U.S. air carriers were obtained from Future Aviation Professionals of American (FAPA), a Las Vegas based firm. Because these figures were only available on an annual basis, the numbers were divided by 2 to get values for each half-year.

New Orders for Consumer Goods (F11) - The series used was the Value of Manufacturers' New Orders for Consumer Goods and Materials in 1972 Dollars, series 8 in BCD. The researchers added values for the first and second quarters to represent the first half of a year. Second half values were obtained by summing the third and fourth quarters for a given year.

Vendor Performance (F12) - The series used was number 32 in BCD entitled, Vendor Performance, Percent of Companies Reporting Slower Deliveries. Because average quarterly values were published, semiannual values were computed by averaging the first and second quarter numbers and the third and fourth quarter numbers.

Net Change in Inventories on Hand (F13) - The series used was titled, Net Change in Inventories on Hand and on Order in 1972 Dollars, series 36 in BCD. Once again, average quarterly values were published, so biannual changes were obtained by averaging

first and second quarter numbers and third and fourth quarter numbers.

Change in Total Liquid Assets (F14) - This series numbered 104 in BCD was titled, Percent Change in Total Liquid Assets, Smoothed Data. The twice-a-year conversion was accomplished by averaging the first and second quarters and the third and fourth quarters.

Manufacturing and Trade Sales (F15) - For this indicator, the researchers used series 57 in BCD entitled, Manufacturing and Trade Sales in 1972 Dollars. The numbers were published by quarter, so the conversion was performed by summing first and second quarter figures and third and fourth quarter figures.

Consumer Credit (F16) - In this case, the series was Ratio, Consumer Installment Debt to Personal Income which is series 95 in BCD. The data for this indicator are published quarterly. The value for the first half of a given year was calculated by averaging quarters I and II. The average of quarters III and IV was the second half value for that year.

Change in Personal Income (F17) - This last series numbered 51-C in BCD was titled, Change in Personal Income, Less Transfer Payments. In 1972 Dollars, over 3-month spans. Quarterly averages for these figures were published. Again, the researchers em-

ployed simple averaging to convert the data. The average of the first and second quarter values for a given year represented the first half-year. Third and fourth quarter numbers were averaged to obtain the value for the second half of the year.

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