MULTIPLE LINEAR REGRESSION VIEWPOINTS
Volume 13, Number 2 Winter 1984

Attention SIG: Paper Abstracts

To be presented at AERA

Chicago, 1985

Time Series ARIMA Models of Undergraduate Grades

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Abstract

The Box-Jenkins approach to time series analysis, a regression method for analyzing sequential dependent observations, is used to determine the most appropriate stochastic model for describing undergraduate grade point averages. The technique was applied to approximately a half century of data from two universities, to investigate models incorporating both regular and seasonal components. Preliminary results suggest a moving average model. Final results will be presented in the paper.

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Objectives

The purpose of this study is to determine the most appropriate stochastic model for describing the temporal variation of undergraduate grade point averages. Using the Box-Jenkins approach to time series analysis, various ARIMA models are constructed from regular and seasonal components. The models are then compared in terms of adequacy and parsimony to select the "best" one. With the availability of appropriate computer software, this technique may have potential application in using a regression approach to analyze a variety of archival educational data.

Perspective

Whenever a phenomena is observed over time, it is often useful to search for temporal patterns within the data. Economists have studied stock market prices, sociologists have examined population levels, and psychologists have investigated changes in the incidence of depression. For such purposes, a variety of time series analysis procedures have been developed, derived primarily from the theory of multiple regression. These techniques require data gathered from a large number of time periods (at least 50, according to McCleary and Hay, 1980). Since archival data is not as commonly analyzed in education as in some other fields, these mathematical approaches are not as widely used in educational research. It is the purpose of this paper to illustrate such an application.

All educational institutions evaluate their students in some manner, but a single group of pupils is not often evaluated fifty times on the same variable, as would be required for a time series analysis. However, a meaningful time series can be realized by obtaining the average grades given during each of the grading periods across a lengthy time span. For about the last half century, many universities and colleges have adopted a 5-point grading scale, using either the letters A through E or the numbers 1 through 5. Some of the institutions calculated, at each grading period, the average of grades awarded to their students, with the interest of maintaining reasonable consistency in their grading standards both among their departments and across time. Approximately fifteen year ago, reports began appearing that a conspicious increase was occuring each year in the grading patterns at many institutions, and numerous ad hoc explanations were proposed (Birnbaum, 1977).

Any "explanation" of a phenomena implies that the phenomena can be adequately described. Mathematical models, and regression models in particular, are appropriate for such a description, but an examination of the literature suggests that most authors rely solely on visual graphs rather than employing mathematical modeling. In this paper, therefore, the use of the stochastic time series approach is used to generate mathematical models that might appropriately describe the entire sequence of available data on grade point data.

Methods and Techniques

While the analysis of time series data has occured throughout most of the present century, major methodological advancements have become practical with the use of the computer. The analysis techniques proposed by Box and Jenkins (1976) have become almost ubiquitous in the time series research community, and it is that methodology that is used to analyze the data in this study.

Models are sought to describe the existing data across the past half century. Some have suggested that grades systemately vary between the terms of a school, and that hypothesis will also be tested, using a model incorporating both regular and seasonal components.

The major purpose of the paper is to describe and illustrate the use of this methodology and the interpretations of its results.

Data Souce. The data was drawn from two midwestern universities which have collected grade data for the past half century. One institution reported the grade point average data for each Quarter Term, while the other reported data from each Semester.

Results and Conclusions

Preliminary results indicate two facets. First, the Auto Correlation Function (ACF), represented by the correlogram, appears not to be well behaved, even with first or second differences. Second, modes incorporating Moving Average components appear to be more promising than those with Auto Regressive components.

At the present time, further analyses are being conducted to generate models which can be defended in terms of adequacy and parsimony.

The results will include Arima parameter estimates for alternative models and autocorrelations for model diagnosis. Results of model forecasts will also be shown.

The conclusions will compare the diagnoses and metadiagnoses of the models. The usefulness and limitations of the ARIMA regression models for educational data will be discussed.

References

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Multiple Regression Analysis with Dichotomous outcome variables: Issues and Examples

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Objectives and Perspective

The purpose of this applied paper is to present 3 examples of the use of multiple regression analysis in situations where the dependent (outcome) variable is dichotomous. While such use of regression is not revolutionary, the examples provide ideas regarding appropriate situations for use and recommendations for presentation of results. For example, in the first study to be presented, the use of the regression approach for analysis was rejected by an APA journal. When the analysis was recast in the traditional discriminant function model, the article was accepted for publication.

Example 1

The research sought to investigate the coping skills of rape victims to determine if some women may be more vulnerable to rape than others. The study investigated five domains: psychosocial competency, mental health, alcohol and drug use, cognitive resources, and physical ability. Seventy-two rape victims and 72 control women were administered psychometric instruments and a biographical inventory. Information was also obtained from significant others. The strongest domain of prediction was psychosocial competency, with the rape victim scoring lower on measures of social presence, dominance, and assertiveness, and higher on external/social locus of control. A past history of alcohol or drug abuse added to the rape-vulnerability profile. Rape victims were more likely to have a past history of psychiatric hospitalization and suicidal thoughts. They did not differ from control women on the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised, but they scored lower on the Achievement via Indpendence Scale of the California Psychological Inventory. Physical ability attributes were not associated with rape vulnerability (Myers, Templer, Brown, 1984).

The proposed presentation will provide ideas regarding data presentation, the use of a stepwise procedure for domain selection and interpretation problems.

Example 2

The problem of unwed adolescent pregnancy has been studied in the past primarily as a symptom of individual psychopathology. These studies yielded equivocal results. Gradually, the broader social context of pregnant teenagers began to be studied. Past research pointed to the importance of the family in contributing to the problem.

The objectives of this study were to investigate whether family variables could discriminate between the families of unwed pregnant and non-pregnant teens. All teen subjects met the research criteria of being unwed, under eighteen years of age, enrolled in local high schools, and living with their families of origin. Thirty-one pregnant teen families and 28 non-pregnant teen families comprised the study sample. Each subject completed the Moos' Family Environment (FES). In addition, each parent completed a questionnaire which included a problem checklist, demographic information, questions about the teen's dating behavior and recent family structural changes.

The hypothesis that incongruence of perception and other family adjustment variables could differentiate the two groups was explored. Pregnant teens were found to have longer boyfriend relationships and fewer problems as rated by the parents. Their family's perceptions were more congruent overall and more congruent regarding family cohesion but less congruent in their perceptions of conflict, organization and control.

Of particular interest in example 2 was the choice of a full model rather than a stepwise procedure. Discussion of such a choice based on the situation is presented.

Example 3

This study examined the effects of acculturation on adolescent development, specifically focusing on daydreaming as one aspect of coping and adaptation. An investigation of two samples of acculturating (Hispanic and Native American) and acculturated (Caucasian) adolescents revealed two variables that, in combination, significantly differentiated the two groups. These two variables, fear of failure daydreams and

distractibility, suggested that acculturating adolescents were more likely to report guilty and fearful daydreaming themes and less likely to report concentration difficulties than their acculturated coparts.

As in the previous examples, presentation of date and interpretability problems are discussed.

Importance

The examples presented provide ideas for alternative analysis in certain situations. Additionally, ideas regarding presentation of results will promote discussion among potential users.

Reference

Myers, M; Templer, D; and Brown, Ric Coping ability of women who become victims of rape. Journal of Consulting and Clinical Psychology, 1984, 52, 73-78.

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Significant Interaction - I Got What I Needed

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The test for interaction is seldom treated as a meaningful endeavor in statistics texts. Hence it would be expected that few researchers test such interesting questions. Two applied journals are surveyed for the number and generic kinds of interaction questions.

Few tested interaction hypotheses (other than seeing if their data met assumptions), although many had basically identified interaction hypotheses in their review of literature. Statistical techniques, such as Multiple Linear Regression, and computer programs exist to assist the researcher in testing interaction, directional interaction, curvilinear interaction, etc.

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Objective. To establish the rightful role of interaction as a critical phenomenon in and of itself.

Perspective. Most research design texts treat interaction as something in the way - something that must be tested - but that hopefully will be eliminated. Few authors lead one to consider the interaction question as a viable question. This is particularly underscored when no text discusses directional interaction.

Data Source. The paper surveys one year's publication of two educational journals. How interaction questions are treated will be tallied, with particular attention to "interesting" interaction questions - those given special names by researchers (e.g. aptitude by treatment interaction, gap analysis, and difference between two correlations).

Conclusions. It is expected that most researchers will obediently test for interaction, but not understand what they have done or why they have done it. Yet some of those researchers will have identified an interaction hypothesis in their review of literature. The few that will have tested for interaction wil have adopted one of the special approaches, not realizing that they could formulate the interaction question in the way they wanted. Finally, it is expected that none of the researchers will have tested for directional interaction, yet a few will have made directional interpretations.

Scientific Importance of the Study. Researchers need to view interaction as a significant phenomenon in and of itself. The ease with which Multiple Linear Regression can test interaction should encourage researchers to look for what they want, in order to find what they need.

LONGITUDINAL ANALYSIS OF SALARY DISCRIMINATION IN HIGHER EDUCATION

by

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ABSTRACT

Legal and statistical issues associated with the use of multiple regression models in faculty discrimination cases in higher education are presented in this paper. Faculty salary models as a function of gender, rank, tenure status, ethnicity, academic discipline, and age variables are analyzed in a longitudinal study covering three years (1982-84) at the University of Northern Colorado. Declining student enrollment during the period saw the size of the faculty drop from a high of 480 in 1982 to a low of 382 in 1984. Results of the exploratory data analysis indicate declining roles for gender and ethnicity variables in explaining salary differences. While the contribution of academic discipline variables in the regression models was statistically significant, results seem consistent with institutional salary policies which were in effect at each point in time.

[1]Authors are faculty members of the University of Northern Colorado.

SUMMARY STATEMENT

A spate of salary discrimination (race, gender, and age) studies using multiple regression models has appeared in the literature during the past decade. The legal profession continues to be concerned about what is perceived as a "contest" between competing statisticians as they argue complex theoretical issues in statistics. The resolution of legal cases only too often seems to depend on the debating skills of an articulate statistician in such areas as the use of multiple regression as a valid legal procedure, use of inappropriate and/or disguised pseudo-evaluative variables, collinearity problems in regression models, uses and abuses of canonical analytic methods, etc. Part one of this paper attempts to put into perspective the major legal and common statistical issues found in salary discrimination cases in higher education.

A second part of the paper will be a longitudinal study of the University of Northern Colorado (UNC) covering the three academic years between 1982 and 1985. With careful attention paid to the concerns raised about regression models in judical cases involving race, gender, and age discrimination, several faculty salary models are formulated using multiple linear regression. The number of faculty vary from a high of 480 in 1982-83 to a low of 382 in 1984-85. The change in the number of faculty members is explained by declining student enrollments during this period. What emerges from the exploratory data analysis are results consistent with the changing role of UNC to a multi-purpose university and corresponding changes in institutional salary policies. Gender and ethnicity variables seem to appear as less important factors in explaining salary differences. While the contribution of academic discipline variables, tenure status and rank variables are statistically significant, their relationships to salary seem consistent with evolving institutional patterns reflecting salary policies. Multiple regression models supported by appropriate follow-up canonical correlation and discriminant analyses were used in the data analysis.

In addition to analyzing salary data obtained as part of the three-year longitudinal study at UNC, specific suggestions are given for subsequent research

in the third part of the paper. The recommendations are sensitive not only to the legal and statistical issues raised in the first part of the paper but are consistent with results obtained from the exploratory data analysis.