ABSTRACT

CARRASCO, LUIS EDUARDO. Analysis of Environmental Impact Statements for Highway Projects in North Carolina. (Under the direction of Dr. Erin Sills and Dr. Gary Blank)

The objectives of this research were (1) to discover associations among economic and environmental factors of highway projects considered in environmental impact statements from 1980 to 1999 produced by the North Carolina Department of Transportation, and (2) study whether this information changed through time, including whether a discernible change occurred when biodiversity regulations were introduced. Multivariate analyses tools were used for this purpose with data collected from 43 EISs. Two main relationships were found, between geographical region and environmental impacts, and between environmental impacts and economic characteristics of projects. While a relationship between geographical region and environmental impacts was expected, the relationship between environmental impacts and economic characteristics of a project was not. This relationship suggests that more environmental impacts occurred or are identified in high-income counties. However, information pertaining to farmland potentially impacted is reported inconsistently in NCDOT documents and cannot be used reliably for comparison purposes. For this reason, environmental impacts in lower-income counties may be seriously underestimated. According to the variables selected for this study, and assuming they effectively represent biodiversity treatment in EISs, logistic discrimination analyses provided some evidence that the CEQ regulation of 1993 concerning treatment of biodiversity had an effect on EISs. This effect might suggest either an improvement in data quality and/or an increase in the attention given to impacts to wetlands and to endangered species included in EISs because of demands from the regulation. Economic factors and impacts to property in EIS, and of geographic location, environmental impacts, and environmental assessment factors showed significant time trends. However, these relationships have not been affected by environmental regulation.

ANALYSIS OF ENVIRONMENTAL IMPACT STATEMENTS FOR HIGHWAY PROJECTS IN NORTH CAROLINA

by

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DEDICATION

"Learning is definitely not mere imitation, nor it is the ability to accumulate and regurgitate fixed knowledge. Learning is a constant process of discovery – a process without end." Bruce Lee

This small piece of work is dedicated, first at all, to my father Mr. Rubén Máximo Carrasco Reyes and my mother Mrs. Luisa Judith Arce Rengifo, for all their support and love to my sister, my brothers, and me during all these years in all aspects of life, for being there in the hardest times, always willing to push me forward.

To my sister Carmen Luisa, my brothers Rubén Jesús, and Alfredo Magno, for all I learned from them, for all the great times, and all the precious moments we shared.

To the memory of my grandfather, Mr. Alfredo Gustavo Arce Moscoso, for all his unconditional support and friendship, for sharing his experience and countless memories, that inspired me to look into other cultures, countries, people and have respect for them.

To all my friends during these school years at La Molina Agrarian University and North Carolina State University.

To Mr. Alexander Hamilton Mencher Hauser, for trusting a rookie like me to lead people to where I never imagined to go by myself before.

PERSONAL BIOGRAPHY

My complete given name is Luis Eduardo Carrasco Arce. I was born in Callao, Perú, in November of 1970. Twelve years later all my family moved to Lima. My parents worked very hard to give my siblings and me the best education they could, and make sure that we could get the same values they received from their parents.

In 1986, and still in the process to overcome asthma, I was introduced, by a close friend of my brother Rubén, to a 91-year-old Cantonese man, Mr. Augusto Xuing, and to Kung Fu, a very old Chinese martial art. I regret not being ready to learn as much as I could from him during those years, but I guess being "blind" at the beginning was part of the process. The most amazing thing I remember from him was something he told me when I was about to pass out because of hard practice – "If you think you are tired, then you are tired". I think that was the greatest lesson I could have from him. I am still trying to apply it in all aspects of my life.

In 1988, I decided to attend the School of Forest Sciences at La Molina Agrarian University, guided by a growing inclination to study nature and conservation in a country rich in natural resources and history such as Perú. Going through high school and undergrad years was not easy, and probably for anybody during those very sad years of violence that my country was facing and which the peaceful Peruvian people were not prepared for. Family values, brotherhood, and friendship helped many people to endure those hard moments and it became, unfortunately, another life experience that now everybody wants to keep in the past.

In 1990, while in school, I started studying Aikido, a Japanese martial art. After three and a half years I received a first-degree black belt. In 1995, I graduated from La Molina with a BS in Forestry Sciences and in 1996 I received the title of Forest Engineer, thanks to a research related to costs and productivity of extraction of a medicinal plant “uña de gato” or “cat’s claw”. I never imagined that most of the working experienced I got in Perú was going to be earned in the Amazon Jungle. In 1996, I started working for Mondina S.A., an environmental consultant for oil companies, as an environmental monitor. Almost one year later, I was planning and managing environmental impact studies for exploration operations. During all those years working in the jungle, I never understood how poverty could exist in a country so rich in natural resources.

In 1999, I decided to continue my professional education, and thanks to many wonderful people at North Carolina State University, I started my Master’s studies under the direction of Dr. Erin Sills, and later, also received guidance from Dr. Gary Blank.

After almost three years I finished the Master’s program in Forestry and now plan to continue at NC State University researching on methods of environmental impact assessment.

Besides the great education I received in this institution, the best experience I received was from all those wonderful people, teachers, students, and friends that I was lucky to meet during these last three years in the United States.

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A todos ustedes:

muchas gracias,

Luis

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LIST OF ABBREVIATIONS

CCA, Canonical correlation analysis

CEQ, Council of Environmental Quality

CEQ 1993, Executive order to all Federal Agencies to enforce assessment of biodiversity

DFA, Discriminant Function Analysis

EIA, Environmental Impact Assessment

EPA, Environmental Protection Agency

EIS, Environmental Impact Statement

EISs, Environmental Impact Statements

LDA, Logistic Discrimination Analysis

NEPA, National Environmental Policy Act of 1969

PCA, Principal components analysis

1 INTRODUCTION AND OBJECTIVES

1.1 Introduction

The purpose of this study is to analyze different components of environmental impact assessment related to quality improvement in environmental impact statements (EISs) for highway projects in North Carolina. Treatment of these components or elements (e.g. wetlands impacts, forestland impacts, assessment of threatened and endangered species) defines the level of compliance or quality achieved according to the National Environmental Policy Act (NEPA) objectives and current technical guidelines.

The quality of EISs has been discussed ever since documents started being produced in the early 1980s. However, systematic studies of EIS quality are not common, and results of recent studies call for future analysis of EIS quality. Tzoumis and Finegold's (2000) study of quality trends over time in draft environmental impact statements in the United States suggests that agencies submitting EISs are not providing quality information consistently through time, according to the rating system used by the Environmental Protection Agency. Atkinson et al. (2000) studied the treatment of biodiversity impacts in a sample of draft EISs, finding inconsistencies and inadequacies in their documentation. Daini (2000) considers similarities in studies across the power sector in Italy and recommends further study of particular sectors to know whether a relationship between any of the topics of an EIS and its quality exists. The proposed research follows that recommendation by focusing on the transportation sector and provides one of the first analyses of EISs in North Carolina.

The first step is to identify relationships among topics related to impacts on biodiversity at two levels: between variables and between groups of variables. A second step is to evaluate whether environmental regulations do or do not have an effect on EIS information. For this step the effect of the "CEQ 1993 regulation on biodiversity" in EISs data will be analyzed.

This research will address these topics by defining and selecting variables from the principal sections of EISs: project information, environmental baseline information, and environmental impacts. To achieve this, a methodology involving multivariate analyses will be used. Relationships among these variables grouped in the new categories of site and project, environmental assessment, and environmental impacts are quantified with principal components analysis and canonical correlation analyses. The effects of an environmental policy on this information will be studied with discriminant analysis and, additionally, analyses of trends through time of variables of significant importance in this process will be carried out.

Results of this study will suggest how to better allocate EIS funding, and how to identify issues where improvement in guidelines for environmental management is required. This study will also suggest whether changes in the treatment of biodiversity impacts have occurred due to the CEQ 1993 environmental policy.

1.2 Objectives

This study has two general objectives: (1) analyze relationships among economic and environmental factors of development projects considered in EISs, and (2) study whether this information has changed over time, including whether there was a discrete change when biodiversity regulations were introduced.

Specific objectives of this study are:

1. Identify relationships among information included in EISs about the site and project, environmental assessment, and environmental impacts.
2. Evaluate the effect of environmental regulations on environmental impact assessment, using as a case the CEQ 1993 regulation on impacts to biodiversity.
3. Analyze trends through time of the environmental and economic variables of EISs that may show sensitivity to environmental policy effects.

2 BACKGROUND

The National Environmental Policy Act (NEPA) was established in 1969 to increase federal environmental oversight of development activities in the United States, due to concern over their negative impacts and lack of regulation. NEPA calls for an environmental impact statement (EIS) when the possibility of an environmental impact resulting from a major federal action has been identified.

After more than 30 years, this process has been applied to numerous activities and, with few modifications and equivalent processes in some states, it is still effective in the US. According to Cambridge Scientific Abstracts (2000), each year the federal government issues hundreds of environmental impact statements which are stored in the database "Digests of Environmental Impact Statements." This database is updated bimonthly with approximately 150 additional studies from different federal agencies. Canter (1996) reports that 8,592 EISs were filed from 1979 to 1991.

As part of the NEPA process, all the environmental impact statements (EISs) require review and comments from several federal agencies in order to ensure environmental protection and minimize, avoid, or plan to mitigate negative environmental impacts before initiating the projects. The goal of this process is to integrate an environmental perspective in every proposed federal decision.

Bregman (1999) points out, however, that the NEPA process might create delays that would seriously impact proposed projects. As most of these studies have information related to a specific time frame, a long administrative process can result in the EISs being out-dated, requiring that they be up-dated at additional costs. In addition, reviewing agencies may request expansions of the EISs, again resulting in additional costs for those amendments or extensions.

Bailey (1997), describing the evolution of EIS in Australia and the US, points out the importance of the relationship between the EIS process and its subsequent environmental management phase, suggesting that this process provides a set of management goals for managers. Thus, the success of its subsequent project management phase depends on the accomplishment of NEPA goals in the EIS phase.

Phillips and Randolph (2000) mention three "key shortcomings" in NEPA's implementation while describing the similarity of goals between NEPA and the recent *ecological management* approach: (a) lack of early engagement of the project developer with the NEPA process through interdisciplinary collaboration, (b) lack of rigorous science application and incorporation of ecological principles and techniques, and (c) lack of encouragement of the administrative process to achieve NEPA's main goals.

They note that specialists criticize the NEPA process because it fails to integrate the project design and environmental management practice, which is the goal of this public policy. The environmental and/or ecological management of projects could be improved by a meticulous analysis of this public system by sector, as different types of projects present their own particularities, with different points to improve in the process.

The transportation sector is one of the most important to study because it involves many different geographical and ecological areas, and it is a vital element of most human economic activities all over the world. Jordan and O'Riordan (2000) mention important negative impacts of this sector: production of global warming gases and local air pollutants, major source of habitat loss, and development of 'greenfield' sites. Canter (1996) shows that 22.1% of all EISs filed in the United States between 1979-1991 were for the transportation sector, the highest percentage among all the federal sectors.

EISs from the Transportation sector were included in Tzoumis and Finegold (2000) study about quality trends of draft environmental impact statements over time in the US. They found that overall quality ratings given by the EPA had decreased over the years among the projects presented by the Forest Service, the Army Corps of Engineers and the Federal Highways administration. Atkinson et al. (2000) studied the treatment of biodiversity impacts in EISs. They reported that biodiversity assessment was lacking in the US, using a relatively small sample of EISs which did not include documents from the Federal Highways Administration. On the other hand, Daini (2000), using cluster analysis, found structures and similarities between EISs for energy projects in Trentino (Italy). He recommended a close study of each particular industry sector to know whether a relationship between any of the elements of an EIS and its quality exists. He concluded that this type of study would be a great tool to formulate or improve guidelines for future individual projects.

3 METHODS

3.1 Introduction

This chapter describes the data collection and analyses required to address the research questions posed in the introduction. These can be summarized as the following seven steps, which are described in greater detail in the remainder of this chapter, after a brief review of methodologies applied in the literature.

1. Identification of topics (categories of information) addressed in EISs, such as environmental site information, project information, and environmental impacts.
2. Selection of specific elements of each topic, such as assessment of threatened and endangered species, forestlands and wetlands impacted, cost of projects.
3. Collection of data from 43 EISs, with each element (variable) coded numerically.
4. Exploratory data analysis with principal components analysis.
5. Evaluation of relationships between groups of variables with canonical correlation analysis.
6. Testing differences before and after 1993 with logistic discrimination.
7. Evaluation of time trends in selected variables of importance.

A principal components analysis was carried out in order to identify preliminary data relationships. Subsequently, two multivariate analyses, canonical correlation analysis and logistic discrimination, were used respectively to find relationships between groups of EIS data and to test the existence of two classes of EISs. Finally, selected variables were analyzed for time trends between 1980 and 1999.

3.2 Previous Methodologies Used in EIS Review

A review of the literature identified two main methodological approaches to evaluate the quality of and patterns in EISs. The current method used by the Environmental Protection Agency (EPA) in grading EISs is also described here.

3.2.1 Cluster analysis

Daini (2000) used cluster analysis to find similarities in data structure from EISs for hydroelectric projects in the region of Trentino (Italy). He found that two out of three sections of EISs were treated consistently: project site information and environmental baseline information. The only section that showed significant differences was environmental impact assessment. These results suggest non-standard treatment of environmental impacts within the same region.

The main purpose of Daini's research was to study consistency between the method of inquiry and the available data. According to him, data in EISs must:

- Refer to criteria and methodologies proposed in specialized literature and in policy debate;
- Characterize EIA studies, sites and projects;
- Be readily available, already present or easily integrated with local environmental regulations.

3.2.2 Grading Based on Biodiversity Criteria

Atkins et. al (2000) developed a simple semi-qualitative method to grade a sample of EISs from different federal agencies in the U.S. in order to evaluate the treatment of biodiversity. Their method consisted of calculating an average of the sum of grades on 19 aspects of the treatment of biodiversity in each study. Using this method, a high score represents a document of high quality. This approach would be recommendable when a good level of agreement exists among a multidisciplinary group. However, it is important to highlight that this scoring system is subjective and depends on the evaluators' criteria and expectations.

3.2.3 Environmental Protection Agency procedure

Tzoumis and Finegold (2000) describe the environmental review process created and employed by the EPA (as required by section 309 of the Clear Air Act) for grading EISs. This method consists of grading EISs according to two scales. The first scale, which evaluates the environmental impacts of the preferred alternative, is a four point rating scale that includes lack of objections (LO), environmental concerns (EC), environmental objections (EO), and environmentally unsatisfactory (EU). The second scale rates the adequacy of the information presented in the EIS. It consists of a three-point scale which includes adequate, insufficient information, and inadequate. According to these authors, this procedure is used by 10 EPA Regional Offices throughout the United States.

3.3 Methodology used in this study

This study evaluates 43 EISs submitted from 1980 to 1999 by the NCDOT to the Environmental Protection Agency (EPA). This collection represents the studies stored and available to the public at the library of the NCDOT. To the extent possible, data were collected from Final EISs (FEISs). However Draft EISs (DEISs) were also used in this study when a final version was not available or did not exist.

In the NEPA process, an EIS is required when "a significant impact on the environment has been identified" because of a federal action or a project with federal funding, in this case road construction. Other documentation in the process such as

Environmental Assessments (EAs) or Categorical Exclusions (CEs) does not address the same environmental impacts in a proposed project.

Large projects, such as a beltline, are built in several construction stages. Before environmental approval for construction, DOT might decide to split a projected beltline in subprojects. These subprojects would involve different levels of environmental impacts. Those subprojects with minimal environmental impacts would only require an EA. If the EA identifies significant impacts, then an EIS would be required. Any subprojects with important impacts on the environment, including any impacts on endangered species or wetlands, would necessarily require an EIS.

CEs are documents required for small projects such as bridges. Impacts to the environment are not addressed in CEs.

3.3.1 Identification of Sections and their Elements in Environmental Impact Statements

After reviewing a sub-sample of 10 EISs, the information that these documents included was divided into the following categories (topics) for purposes of this study: site and project information, environmental assessment information, and environmental impacts.

Each of these categories includes information that is commonly assessed in studies of EISs. From all the variables available within each category, the following were pre-selected for this study[1]:

1. Site and Project

[1] A complete list of variables, on which data were collected but not pre-selected can be found in Appendix A.

- *Type* refers to whether the project is new highway or an improvement to a highway.
- *Right of way* is the width of projected road measured in feet plus an additional margin of space in case changes in design are required.
- *Road length* is the length in miles of the designed road project that is denoted in the EIS as the preferred option to build.
- *Cost of right of way* is the cost of acquisition of land within the right of way area of a preferred alternative, in 1982 dollars.
- *Cost of construction* is the cost of workforce, materials, and engineering for the construction of the preferred alternative (in 1982 dollars).
- *Type of area* refers to whether the project was designed for a rural or an urban area[2].
- *Physiographic province* refers to the principal physiographic provinces in North Carolina: Blue Ridge, Piedmont, and Coastal Plain.
- *Income per capita*. Average income per person per county in NC. Results from dividing the total income of one county by the total population. These data were not collected from the studies but rather from the Bureau of Economic Analysis[3].

2. Environmental assessment

- *Specialist ratio* is the ratio of environmental professionals to total professionals involved in the process of preparing the EIS.

[2] This variable was not considered in any of the statistical analysis discussed here because of low significance in a pre test of principal components.
[3] U.S. Department of Commerce - Bureau of Economic Analysis: http://www.bea.doc.gov/bea/regional/

- *Endangered species* is the number of species mentioned with a designated federal conservation category, such as threatened or endangered. The fact that a particular species is mentioned in a study does not mean that it will be impacted by the project, otherwise it would be considered as an impact variable.
- *Field surveys* is the number of field studies that sought evidence of endangered or threatened species in the area of influence of the proposed project or study corridor.
- Environmental impacts
- *Forestlands impacted* is the estimated area of forestland that will be modified, partially or entirely, because of the construction of the road or preferred alternative.
- *Wetlands impacted* is the estimated area of wetland that will be modified, partially or entirely, because of the construction of the road.
- *Residences relocated* refers to the number of residence properties that are located within the right of way of the projected road and need to be relocated to allow the road construction.
- *Businesses relocated* refers to the number of business properties that are located within the right of way of the projected road and need to be relocated to allow the road construction.
- *NGOs relocated* refers to the number of non-profit organizations properties that are located within the right of way of the projected road and need to be relocated.
- *Public participation* refers to the number of comments received by the agency in charge of the EIS as counted by the agency.

- *Year of submission* is the year the draft EIS was sent for review to the Council of Environmental Quality for evaluation.

Important impacts such as impacts to farmlands were aimed to include in this research, however, EIS showed different denominations for farmland impacts that might overlap each other[4] or other different land uses. For instance, *prime farmlands* are classified by soil type, not by land use, so it may also include developed land. On the other hand, some counties may not have a soil or farmland classification so these might not be usually accurate.

3.3.2 Variables selected, transformation and normalization

From the data collected, only the following variables were selected for the analysis: *physiographic province, income per capita, cost of right of way, cost of construction, specialists, species addressed, surveys for species, forestlands impacted, wetlands impacted, residences relocated, and public comments*. These data were available for most projects.

Many of the site and project variables are correlated with the scale of the project. In order to distinguish their effects from the effects of project scale, they were normalized as follows. Cost of right of way, cost of construction, acres of forest impacted, acres of wetland impacted, and residences relocated by project were divided by the road length. The preferred reference variable would have been area of right of way, however, data for this variable were not consistent across studies, maybe because of different criteria used to estimate impacts to types of land as described above.

The new variables after transformation were:

[4] See table showing different denominations of Farmlands in EIS in Appendix A.

- Relative Cost of Right of Way (CRW)
- Relative Cost of Construction (CC)
- Relative Forestlands Impacted (FPM)
- Relative Wetlands Impacted (WPM)
- Residences Relocated (RES)

Nominal variables such as Physiographic Province were transformed to three dummy variables, Coastal Plain, Blue Ridge and Piedmont. Blue Ridge was combined with Piedmont as there were only two projects in the former region. These projects occurred before the year 1993.

Most of the variables selected for the multivariate analyses showed non-normal distributions. Normalization of data was necessary in order to interpret the results with more confidence in a parametric test. Each variable's distribution was determined using normal distribution graphs and normal quantile plots[5]. The normalization methods used are shown next to each type of distribution found.

Variable's distribution	Normalization method
Exponential	Square root or Logarithmic
Logarithmic	Logarithmic

Each variable's distribution and the normalization method used are listed in Appendix B. For the variables with exponential distribution, square root or logarithmic normalization were chosen based on the final distribution of the data after transformation.

[5] See Appendix B for test of normal distributions.

3.3.3 Other variables used

The other information gathered from the studies was whether the data on each variable had been collected at all, that is, missing values. A new variable measuring the "completeness" of the study was created using the following procedure:

- In the original database, *missing data* in any study and in any field were coded as –1, and existing data were kept with their original numeric values.
- A second database was created from the original, transforming the values for each variable. All pre-existing data were transformed to 1, and missing data values were transformed to 0.
- The new transformed values for each study (or record) were totaled.
- The total value for each record was divided by the highest value found among all the records, thus, data for this new variable range from 0-1.
- The variable was labeled Completion index (CI)

The CI is based on the following variables[6]:

- Average right of way
- Study corridor width
- Minimum right of way width
- Number of stream crossings
- Species addressed in the report
- Field searches for threatened and endangered species assessment
- Undisturbed or forestland impacted
- Agricultural/cleared land impacted

[6] Details about these variables can be found in Appendix A.

- State and locally important farmlands impacted
- Prime farmlands impacted
- Farmland impacts
- Urban/disturbed/developed land
- Wetlands impacted
- Stream impacts
- Open waters impacts
- Surface waters impacts
- Flood plain encroachment
- Number of Noise receptors (no noise barriers)
- Number of conservation areas affected
- Parks impacted
- Evaluation of indirect, secondary and cumulative impacts
- Study of mitigation

3.3.4 Sample size, level of significance and software used

The total sample size for the analyses described below was 43 EISs. Each of the statistical analyses was performed using SAS. An alpha level of 0.01 was considered very significant whereas 0.15 was considered significant for the Principal Component Analysis, Canonical Correlation, Trend Analysis, and Logistic Regression.

3.3.5 Identification of relationships among single variables - Principal Components Analysis

According to Manley (1983) and Wichern (1988), Principal Components Analysis (PCA) is designed to reduce the number of variables that need to be considered to a small number of indices (called principal components) that are linear combinations of the original variables. This method explains the variance-covariance structure of a set of multivariate data. It is mainly used for data reduction and interpretation before applying other methods of analysis. Wichern (1988) mentions that the PCA often reveals relationships that were not previously suspected and allows interpretations that would not ordinarily result.

In this study, PCA was used principally to identify linear relationships of importance in the dataset. Second, PCA was used to infer the statistical importance of each variable, as identified by its eigenvector in each principal component. Partial correlations between variables were also examined to support interpretation of each relationship.

3.3.6 Identification of relationships among groups of variables with Canonical Correlation analysis

This technique is based partially on PCA. Manley (1983) and Wichern (1988) say that in Canonical Correlation, the variables (not the individuals) are divided into groups and interest centers on the association between two groups at a time. Three groups of variables were evaluated with canonical correlations:

- Site and Project
- Environmental Impacts
- Environmental Assessment

The objective was to find whether any pair of groups showed a statistically significant correlation. A significant canonical correlation between two groups or sets of data may suggest a cause-effect relationship. For instance, a high canonical correlation between site and project and environmental impacts would suggest that the occurrence of environmental impacts is linked to some of the sub-variables in site and project, e.g. physiographic region (piedmont). In this case, as this last variable is fixed in space and time, and the associated variables (environmental impacts) are not fixed but occur at a particular time, this suggests a cause effect relationship. However, it is important to be familiar with the nature of each variable in order to arrive to a reasonable interpretation.

An association and its strength are defined by the squared canonical correlation (R^2) between the canonical variables (or linear combinations), with its statistical significance defined by the *p-value*. Further interpretation of each canonical correlation was supported by calculating the partial correlations between each original variable and each linear combination or canonical variable.

3.3.7 Verification of classes among the observations with Logistic Discrimination

In this study, a logistic discrimination analysis (LDA) is used to identify whether a group separation exist among the 43 EISs reviewed, using two groups:

- Pre-1993 - EISs submitted until 1993 (including 1993)
- Post-1993- EISs submitted after 1993

According to Khattree and Naik (2000), the logistic discriminant approach consists of performing logistic regression of the categorical variable, indicating population membership, on various explanatory variables. In this case, our interest centers on whether a study belongs to the pre-1993 or post-1993 “populations”. Explanatory variables are drawn from the three categories discussed above. Some of these explanatory variables are themselves qualitative and represented in the model as dummy variables. The model to be estimated is written in terms of the *logit* function, defined as:

$$\boldsymbol{logit\ (\pi) = \log_e (\pi / 1- \pi)}$$

where π is the probability of a study belonging to the pre-1993 population and $1 - \pi$ is the probability of belonging to the post-1993 population. The dependent variable y is defined as $y = 1$ for pre-1993 studies, and $y = 0$ for post-1993 studies. Therefore, the distribution of $\boldsymbol{y}$ is binomial. The *logit* function is assumed to be a linear function of $\boldsymbol{k}$ explanatory variables,

$$\boldsymbol{logit\ (\pi) = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k}$$

which provides the basic underlying model for the estimation of unknown parameters $\boldsymbol{\beta_0, \ldots, \beta_k}$ and the decision rule for discrimination and classification. The statistical significance of the corresponding $\boldsymbol{\beta}$ parameters of each individual explanatory variable is judged by Wald's Chi-square statistic.

3.3.8 Recognition of trends through time on selected variables

After identifying correlation among variables in the multivariate analyses, correlation between time and variables considered important such as completion index, impacts to forestlands and wetlands, and principal components were performed. A binary variable for class membership is defined as follows:

Class name: Pre-1993

With the following values:

0 for Post-1993

1 for Pre-1993

The time variable was defined in years, from 1980 to 1999. The 43 EISs were used in this analysis. The significance of the effect of time or class given by the EISs period of time membership (pre-1993 and post-1993) over each important variable was defined by its p-value. This analysis was performed using a main effect model, where CI is the independent, or response, variable and Year (time), and Pre1993 are the effects or nominal variables. Evaluating a trend through time of CI, for instance, a significant increasing effect of time over CI would suggest an increasing tendency of the amount of environmental information in EISs. A significant effect of the variable class over CI would suggest an influence of the CEQ 1993 regulation on environmental data completion. Similar questions were posed for other variables that showed significance in the logistic discrimination analysis.

3.3.9 Remarks on methodology and its significance

The results of applying these statistical methods are included and discussed in the next two sections. In chapter four, each method's relevant results are explained, as each analysis is intended to show relationships between data in different categories. In chapter five, a discussion of each individual result is given as well as appreciation of them in order to get a more complete outlook of the EIS process in NC and their significance in EIA practice.

4 RESULTS

4.1 Introduction

The main objective of the statistical analysis used in this study is to find relationships or associations between variables included in EISs classified in three sections: site and project, environmental assessment, and environmental impacts. The amount of variables described or mentioned in EISs that may have importance from an environmental point of view could be different from the amount of variables that are relevant in the EIS decision-making process, and may not be completely reflected in this study. However, the analyses proposed in the previous chapter are a useful first assessment of relationships and characteristics of EISs and the influence of the CEQ1993 in environmental assessment practice by NC-DOT.

Table 4.1 shows simple statistics of the quantitative variables used in the four analyses that are described in this chapter: principal components analysis (PCA), canonical correlation analysis (CCA), discriminant function analysis (DFA), and time trend analysis. Acronyms for each variable are also shown below.

Table 4.1 Simple Statistics of Quantitative Variables

Statistic	Income per capita (IPC)	Cost of Right of Way (CRW)	Cost of Construction (CC)	Specialists (BIO)	Endangered Species (ES)	Field Surveys (FS)	Forest per mile (FPM)	Wetlands per mile (WPM)	Residences Relocations (RES)	Public comments (PC)	Completion Index (CI)
Mean	17830.02	18916045.14	77090559.37	0.11	3.02	1.30	22.11	2.63	75.46	139.26	0.90
Standard Deviation	5787.83	21175057.30	62619015.93	0.08	2.75	2.34	18.31	4.49	84.53	250.95	0.10
Maximun	35759.00	106789055.19	259014201.10	0.38	14.00	11.00	106.74	22.77	336.00	1120.00	1.00
Minimun	8308.00	681145.11	1209279.37	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.59

Table 4.2 describes two categorical variables related to EIS projects used in this study and their distribution, according to type of area[7] and according to physiograhic province.

Table 4.2 Distribution of rural and urban projects according to physiographic province

		Physiographic Province			
		Piedmont (PID)	**Coastal plain (CP)**	**Blue ridge (BR)**	**Total type of area**
Type of Area	Rural	21 (66%)	7 (22%)	4 (13%)	32
	Urban	9 (82%)	2 (18%)	0 (0%)	11
	Total Phy. Prov.	30	9	4	43 (100%)

This information suggests that most of the EISs were done for rural projects. In fact, almost half of the 43 EISs reviewed were for rural projects in the Piedmont. Likewise, there were more rural projects than urban projects in the Coastal Plain and only rural projects in the Blue Ridge.

Table 4.3 (below) shows simple statistics for the two periods of our interest, Pre 93 and Post 93. The average length of road constructed, and subsequently forestland and wetlands predicted to be impacted are higher in the second period of time, after the CEQ 1993 regulation was given. From 1980 to 1993, 362 miles of road were built, more than in the period post 1993 (216 miles). The amount of forestland predicted to be impacted by road construction was very similar in both periods of time (100,323 acres before 1993, and 98,948 acres after 1993). This observation is also valid for wetlands (2,147 before 1993, against 2,207 after 1993).

[7] See section 3.3.1 for description of Type of Area.

Table 4.3 Simple statistics for Project length, predicted impacts for forestlands and wetlands before and after CEQ 1993

	Pre 93 (n=31)			Post 93 (n=12)		
	Road length miles	**Forest acres total***	**Wetland acres total***	**Road length miles**	**Forest acres total***	**Wetland acres total***
Average	11.68	276.28	29.75	17.94	389.93	53.13
Total	362.00	100323.40	2146.56	216.00	98948.05	2206.53
St-Dev	6.17	114.64	155.72	10.01	62.26	129.82
Maximum	27.30	1587.20	166.20	39.40	801.65	210.50
Minimum	1.00	0.00	0.00	5.30	3.75	0.26

* Shows total area per project

Table 4.4 shows a similar trend for standardized predicted impacts by length of road. In average, the length of highways projects was longer after 1993 than before that. Predicted impacts to forestlands and wetlands per mile of project were slightly bigger Post 1993.

Table 4.4 Average of Predicted Impacts to Forestlands and Wetlands before and after CEQ 1993

	Pre 93 (n=31)			Post 93 (n=12)		
	Road length miles	**Forest acres/mile**	**Wetland acres/mile**	**Road length miles**	**Forest acres/mile**	**Wetland acres/mile**
Average	11.68	20.48	2.43	17.94	21.05	2.94
Std. Dev.	6.18	19.93	4.59	10.02	14.01	4.38

On the other hand the average number of endangered species addressed in EISs pre 1993 was 1.98 and post1993 was 4.22, with a difference of 113% with respect to pre 1993 EISs. Average number of specialists per year pre 1993 46%, post 1993 60%, the increment was of approximately 30%.

4.2 Identification of groups of variables

4.2.1 Relationships between variables - Principal Components Analysis

Principal components analysis is applied to the transformed variables listed in Appendix B and defined in sections 3.3.1 and 3.3.2 in addition to the completion index. The values of the eigenvectors for the first two principal components are shown below. The first two components explain approximately 50% of the variance of the multivariate data. The first component explains 25.8% of the variance by itself. The rest of the components contribute relatively little to the overall variability, which can be attributed to the large number of variables used in this analysis. Results for other components are shown in Appendix C.

Table 4.5 Eigenvalues of the Correlation Matrix for First Two Principal Components

Principal Component	Eigenvalue	Difference	Proportion	Cumulative
1	3.097	0.324	0.258	0.258
2	2.773	1.493	0.231	0.489

The coefficients for each variable in the first and second principal component are shown in Table 4.6. From the first component, we can observe the importance of the following variables: income per capita (0.391), cost of right of way per mile (0.488), cost of construction (0.443), and residential relocations (0.369). It can be interpreted from this first component or linear combination that variables related to the economic characteristics of the project and site (IPC, CRW, CC), and impacts primarily to property (RES) and secondly to forestlands (FPM) in the piedmont are related. This is supported by the bivariate correlation between CRW and RES of 58%, one of the highest among the data set.

The second principal component stresses the importance of project and site as in geographic location, income per capita (0.210), linked to environmental assessment variables such as specialists in the team (0.373), endangered species assessment (0.467), field surveys performed (0.402), as well as impacts to wetlands (0.416) and to forestlands (0.232). A variable of importance in this analysis is the completion index, which has a moderate weight in the first component (0.266) and the second one (0.229). This suggests that completeness of a study is related to environmental as well as economic characteristics of a project.

Table 4.6 Eigenvectors of Principal Components Analysis

Variable	Principal Component 1	Principal Component 2
CP	-0.273	0.340
IPC	0.391	0.210
CRW	0.488	-0.012
CC	0.443	0.130
BIO	-0.053	0.374
ES	0.021	0.467
FS	-0.137	0.402
FPM	0.249	0.232
WPM	-0.073	0.416
RES	0.369	-0.111
PC	0.205	-0.112
CI	0.266	0.229

Figure 1 plots the EISs by the first two principal components. The data are scattered in a close-to a circular pattern, because of the similar proportions of variance explained by the first two components. It is important to mention that EISs' membership to classes (pre and post 1993) was not included as a variable in this analysis. The EISs completed before 1993 range from low to high values along the first component, and low to medium

values in the second one. On the other hand, the EISs completed after 1993 ranged from medium to high values in the first component and medium to high values in the second one. This suggests differences in EISs pre and post 1993, as there is less variation in EISs post 1993 (more clustered group) than in EISs pre 1993 (widespread group) because of economic and environmental factors as explained by the first and second principal component. In spite that the figure suggests a division of EISs in two classes, is it also possible that the post-93 EISs are more tightly grouped just because there are fewer of them. The discriminant function analysis described in section 4.2.3 provides a more robust explanation of the existence of classes in the EISs from 1980 to 1999.

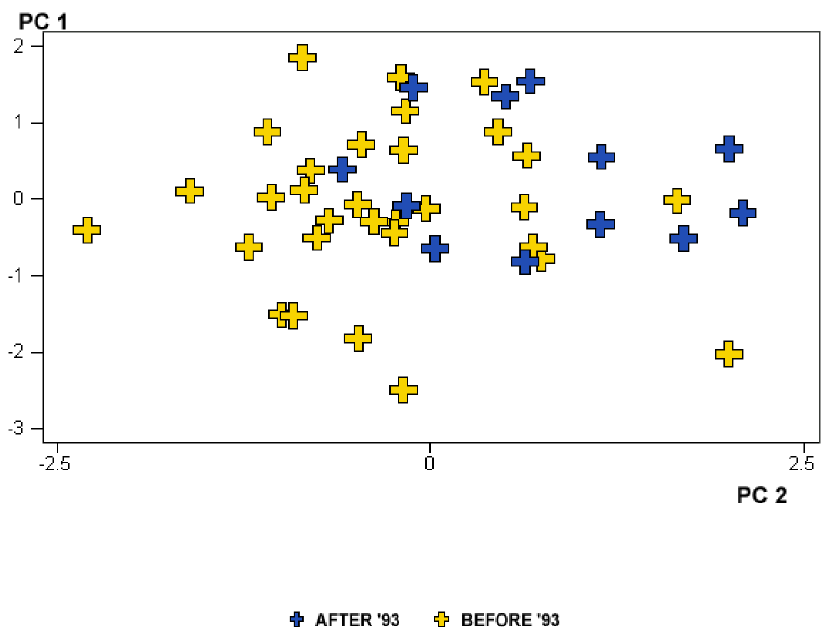

Figure 1: Plot of First Principal Component vs Second Principal Component. Axes are standardized scores for each EIS in each principal component.

4.2.2 Identification of relationships among groups of variables using canonical correlation functions

In the previous step, relationships between single variables were found and linear combinations of them that may explain different interactions were analyzed. In this subsection, the same variables are grouped in three categories according to their characteristics and preponderance in EIS, site and project, environmental impacts, and environmental assessment. Each category is composed by the following variables:

- Site and project: Piedmont, Coastal Plain, cost of right of way, cost of construction, income per capita.
- Environmental impacts: forestlands impacted per mile, wetlands impacted per mile, residences relocated per mile.
- Environmental assessment: Specialists in team, endangered species addressed[8], public comments, completion index.

The canonical correlation analysis shows in this section whether there is a significant relationship between the groups of variables.

4.2.2.1 Site and Project vs. Environmental Impacts

Canonical correlation analysis is used first to test for statistically significant correlations between linear functions of variables in two groups of categories: site and project and environmental impacts. Table 4.7 shows that the first resulting canonical correlation between these two sets of variables is moderate (0.560) and very significant correlation according to its p-value (<.0001). The second canonical correlation shows a

[8] Section 3.3.1 details why endangered species is considered an environmental assessment variable.

small correlation (0.383), and also very significant (p-value = 0.0019). The first canonical correlation describes 61.2% of the variability between these two sets of variables, and the second one explains 29.8% (Table 4.7).

These results suggest that the environmental impact variables (impacts to wetlands, forests and urban property) are related to the geographic location of the project (in the piedmont or in the coastal plain). Furthermore, environmental impacts are related to economic characteristics of the project, represented here as costs of construction, costs of right of way, and income per capita.

Table 4.7 Canonical Correlation Analysis for Site and Project vs. Environmental Impacts

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Pr > F	Eigenvalue	Proportion
1	0.748	0.694	0.068	0.560	**<.0001	1.271	0.612
2	0.618	0.588	0.095	0.383	**0.0019	0.620	0.298

The analysis reported two linear functions or canonical functions with coefficients for each variable within each group of variables. These standardized canonical coefficients show the importance of each variable in their canonical linear function (Table 4.8). In this case, the first canonical correlation coefficients for site and project stress the importance of the variables coastal plain (CP) and cost of right of way (CRW). On the other hand, the coefficients for the environmental impacts set stress the importance of impacts to wetlands (0.987) over the other two variables (forest impacted per mile and residential relocations).

The second canonical function, although with a small correlation, shows the importance of the variables Coastal Plain, cost of right of way, and residential relocations as in the previous relationship. However, it gives more importance to impacts to wetlands than to forestlands.

Table 4.8 Coefficients for Canonical functions: Site and Project vs. Environmental Impacts

Set	Variables	Coefficients for each Canonical Function	
		1st Function	2nd Function
Site and Project	PID	0.333	0.079
	CP	1.216	-0.251
	CRW	0.625	0.821
	CC	-0.023	0.117
	IPC	-0.110	-0.107
Environmental Impacts	FPM	-0.121	0.404
	WPM	0.987	-0.301
	RES	0.368	0.818

4.2.2.2 Site and Project vs. Environmental Assessment

This subsection shows whether there is or not a canonical correlation between site and project and environmental assessment. The canonical correlation between these two sets of variables is moderate (R^2=0.43) and significant at 15% (p-value=0.053). The second canonical correlation is small and not significant.

Table 4.9 Canonical Correlation Analysis for Site and Project vs. Environmental Assessment

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Pr > F	Eigenvalue	Proportion
1st Function	0.653	0.547	0.088	**0.427**	***0.0528**	0.744	0.580
2nd Function	0.524	0.444	0.112	0.275	0.3723	0.379	0.296

The coefficients shown in Table 4.10 for the first canonical correlation for site and project stress the importance of the variables Piedmont (-0.610) and cost of right of way (-0.608) opposed to the variables income per capita (0.39), cost of construction (0.371), and coastal plain (0.284).

Table 4.10 Coefficients for Canonical functions: Site and Project vs. Environmental Assessment

Set	Variables	Coefficients for Canonical functions	
		1st function	2nd function
Site and Project	PID	-0.610	-0.134
	CP	0.284	-0.229
	CRW	-0.608	-0.070
	CC	0.371	-0.055
	IPC	0.390	1.061
Environmental Assessment	BIO	-0.146	0.415
	ES	0.703	0.204
	FS	0.589	-0.205
	PC	-0.162	0.397
	CI	-0.336	0.691

On the other hand, the coefficients of the first canonical function for the environmental assessment group, give importance to the variables endangered species (0.703), field surveys (0.589), opposed to completion index (-0.336) (Table 4.11).

4.2.2.3 Environmental Impacts vs. Environmental assessment

The first canonical function shows a squared correlation from moderate to low (0.339) between the variables environmental assessment and environmental impacts (Table 4.11). The significance of the second correlation shown is low and not worthy to interpret. However, the p-values for the first two canonical correlations are significant at 15% (0.014 and 0.082).

Table 4.11 Canonical Correlation Analysis and Significance for Environmental Impacts and Environmental Assessment

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Pr > F	Eigenvalue	Proportion
1st Function	0.582	0.462	0.102	0.339	***0.014**	0.512	0.552
2nd Function	0.470	0.411	0.120	0.221	*0.082	0.284	0.858

The coefficients for the variables in environmental impacts stress the importance of impacts to natural resources, forest per mile (0.239) and wetlands per mile (0.358) opposed to impacts in urban resources as in residential relocations (-0.885) (Table 4.12).

In the case of the canonical variable environmental assessment and its individual variables, the importance relies on the specialists (0.371), and number of endangered species addressed in the report (0.617), as opposed to the completion index (-0.606) (Table 4.12).

Table 4.12 Coefficients for Canonical Functions: Environmental Impacts vs. Environmental Assessment

Set	Variables	Coefficients for each Canonical Function	
		Environmental Impacts	
		1st Function	2nd Function
Environmental Impacts	FPM	0.239	0.613
	WPM	0.358	0.521
	RES	-0.885	0.422
Environmental Assessment	BIO	0.371	-0.524
	ES	0.617	0.664
	FS	0.167	0.208
	PC	-0.169	-0.002
	CI	-0.606	0.602

4.2.3 Recognition of classes using discriminant analysis (logistic discrimination)

The objective of this analysis is to identify variables that describe and classify EISs into the pre and post-1993 categories. While the logistic discrimination does return a linear model, it is not used here to predict EISs with future data but rather to verify whether the division of EIS observations into pre 1993 and post 1993 exist according to the data collected.

The set of variables listed to in Table 4.1 were selected with a stepwise logistic discrimination to classify each EIS into pre and post-93 categories. The significance used to select variables for the classification model was 0.25. This high significance was chosen to make the most of any information that the collected data could offer and, to avoid discarding important relationships that would not show up because of low statistical power.

After the stepwise selection, only four variables out of the thirteen entered were found to be statistically significant to classify the data: income per capita, coastal plain, endangered species count, and impacts to wetlands per mile of road (see table below).

Table 4.13 Summary of Stepwise Selection

Step	Effect		DF	Number In	Score Chi-Square	Wald Chi-Square	Pr > ChiSq
	Entered	Removed					
1	IPC	-	1	1	5.234	.	0.022
2	CP	-	1	2	7.799	.	0.005
3	ES	-	1	3	1.382	.	0.240
4	WPM	-	1	4	2.146	.	0.143

With these four variables a logistic discrimination was performed. The significance of each individual variable is given by the probability of their Wald-Chi Square value (Table 4.14). The discrimination of EISs in two groups is significant (p-value = 0.045).

The variable income per capita shows high significance (p-values = 0.010), while the variables coastal plain, endangered species, and wetlands per mile (p-values = 0.013, 0.082, and 0.125, respectively) are significant at 15% level.

Table 4.14 Significance of Variables Estimates

Parameter	DF	Estimated Coefficients	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	3.475	0.985	12.435	0.000
CP	1	-3.756	1.518	6.121	0.013
IPC	1	-0.334	0.130	6.607	0.010
ES	1	-0.357	0.205	3.029	0.082
WPM	1	0.327	0.213	2.349	0.125
Wald Test	4			9.759	0.045
Score	4			15.786	0.003
Likelihood ratio	4			17.789	0.002

According to the estimated coefficients the linear model for assigning one EIS to the class Pre-1993 (1 for pre-1993 and 0 for post 1993) is given by the following logistic expression:

***logit*[9] (Pre 1993) = 3.475 - 3.756 CP - 0.357 ES - 0.334 IPC + 0.327 WPM**

Using this model, the observations were classified using 72% of probability of belonging to class Pre 1993[10].

[9] ***logit* (π) = log $_e$ (π / 1- π)**
[10] The probability of 72% comes from dividing the number of observations (EISs) until 1993 (31) over the total number of observations (43).

Table 4.15 Classification* Table

		Actual response		
		Pre 1993	Post 1993	Total
Predicted response	Pre 1993	23	8	31
	Post 1993	3	9	12
	Total	26	17	43
Correctly classified observations: 100 (23 + 9)/43 = **74.4 %** *Using a 72% probability to classify after first classification using 50%				

The classification shown in Table 4.15 explains the performance of the logistic model in classifying the EISs into the two time periods. Of the 43 studies, 74.4% are classified correctly by this logistic model with the four selected variables. This analysis is designed to probe whether a division of classes exists. The variables selected by the step-wise regression for this analysis are the principal ones in this sample set that explain statistically the classification of EISs into two groups given by the 1993 CEQ regulation on biodiversity. In order to support the previous analysis, a non-parametric discriminant function analysis was performed with all the thirteen variables suggesting also the existence of two classes, as shown in Table 4.16.

Table 4.16 Number of Observations and Percent Classified into CLASS

		From Class		
		Pre 1993	Post 1993	Total
To Class	Pre 1993	30	1	31
	Post 1993	4	8	12
	Total	34	9	43
Correctly classified: (30 + 8) /43 = 88.4%				

This classification shows a performance of 88.4 %. However, the significance of this test cannot be easily determined in the case of a nonparametric discrimination analysis.

In summary, the logistic discrimination suggests the division of the EISs in two natural classes, before 1993 and after 1993. This division is explained by four variables in decreasing order of importance: coastal plain, endangered species addressed, income per capita, and wetlands impacted per mile, according to the size of the variables' coefficients in the model. Physiography (Coastal Plain) is the most important variable in the discriminating the data into classes. Before and after 1993 there were more projects in the Piedmont than in the Coastal Plain, however the proportion of projects in the Coastal Plain after 1993 increased. Endangered species, and income per capita seem to discriminate in the same direction as when a project occurs in the Coastal Plain. This suggests that there were more endangered species assessed in projects after 1993, and that projects tended to be in areas of higher income per capita. The model also suggests that before 1993 there were more predicted impacts to wetlands per mile of project. The significance of WPM and ES suggests that differences in predicted impacts to wetlands and assessment of endangered species were significantly different (at 15%) to classify EISs in these two periods of time. Table 4.17 shows a summary of these two variables.

Table 4.17 Distribution of Environmental impacts as predicted in EISs before 1993 and after 1993

	PRE 1993		POST 1993	
	Mean	**St. Dev.**	**Mean**	**St. Dev.**
Wetlands per mile				
Piedmont*	23	21	26	15
Coastal plain	15	10	17	10
Endangered species addressed				
Piedmont*	2	2	3	1
Coastal plain	3	2	7	6
Number of EIS				
Piedmont*	26		8	
Coastal plain	5		4	
* Includes observations in the Blue ridge				

The results of the model, especially in the case of wetlands per mile are contrasted by these simple statistics as, in average, more impacts to wetlands were predicted after 1993. It is important to consider the small sample size used in this analysis in comparison to the number of variables used. For instance, the fact that in the second period there are less observations (EISs) suggests that the discrimination was based more in differences of location of projects, as the proportion of projects in the Coastal Plain increased after 1993, as mentioned before, and secondly because of differences in endangered species addressed, income, and wetlands impacted. For these reason, interpretations of these results will be addressed carefully in the next chapter.

4.2.4 Recognition of trends through time among variables

A time trend analysis was performed in order to determine whether EIS variables changed systematically over time. This test was performed primarily with the dependent variable completion index (CI). This variable characterizes the amount of information in each EIS, relative to the most complete EIS recorded. Other time trends analyzed were impacts to wetlands per mile (WPM), impacts to forestlands per mile (FPM), and endangered species addressed in the report (ES). A more extended description of the predicted impacts to wetlands and forestlands in EIS in the two periods of study is given in section 4.1.

4.2.4.1 Completion Index

The trend analysis shows that Completion Index (CI), or measure of information completeness, is increasing through time (see Figure 2), but this increase is not significant (p-value 0.323). Likewise, there is no significant effect of the class, pre 1993 or post 1993, on CI (p-value 0.559).

Table 4.18 Significance of main effects of Time (year) and classes (pre and post 1993) on CI and overall test

Effect	Num DF	Den DF	F Value	Pr > F
YEAR (random)	1	29	1.01	0.322
CLASS	1	29	0.35	0.559

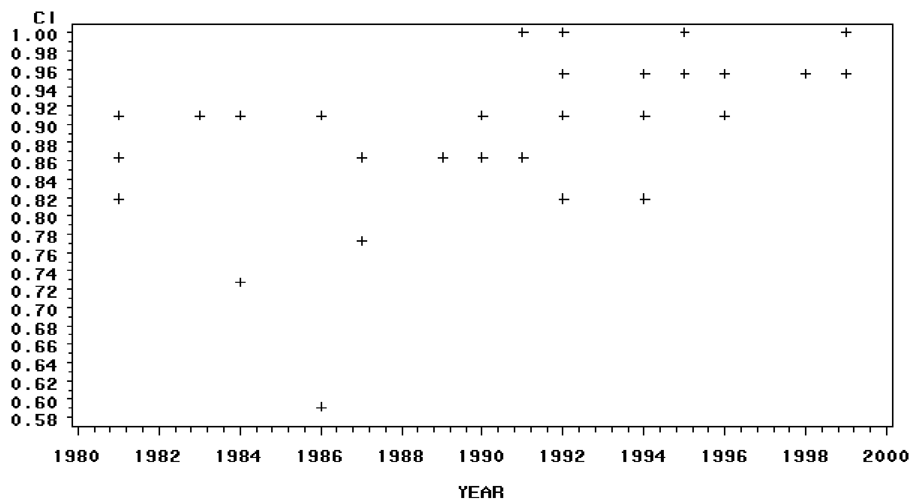

Figure 2: Trend Completion Index (CI) through Time

4.2.4.2 Forestland Impacts

Impacts to forestlands showed a positive significant effect of time (Year), but the effect from classes was not significant.

Table 4.19 Significance of main effects of Time (year) and classes (pre and post 1993) on FPM and

Effect	Num DF	Den DF	F Value	FPM > F
YEAR (random)	1	29	5.90	0.022*
CLASS	1	29	0.35	0.204

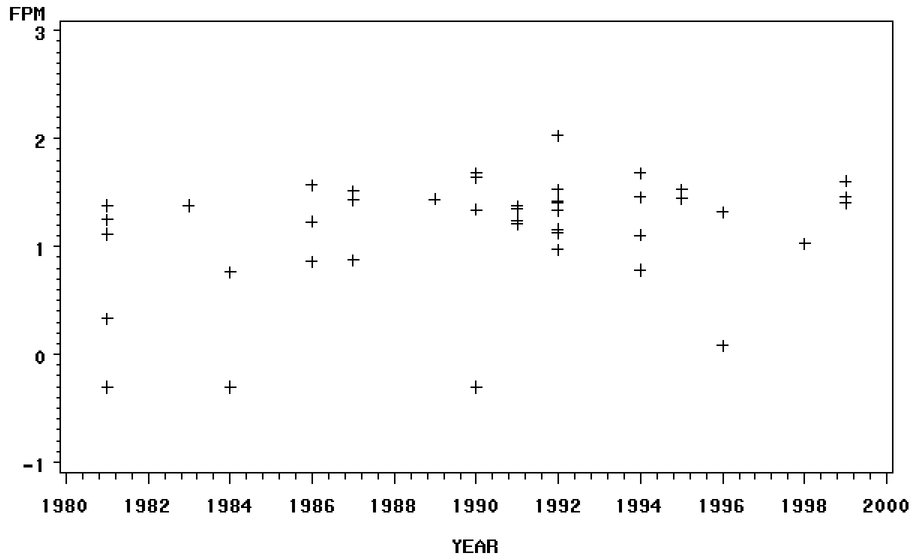

Figure 3: Trend Forestlands impacts (FPM) through Time. Values in vertical axis are log-transformed

4.2.4.3 Wetlands

Predicted impacts to wetlands did not show a trend as an effect of time or of classes.

Table 4.20 Significance of main effects of Time (year) and classes (pre and post 1993) on WPM

Effect	Num DF	Den DF	F Value	Pr > F
YEAR (random)	1	29	0.13	0.722
CLASS	1	29	0.19	0.668

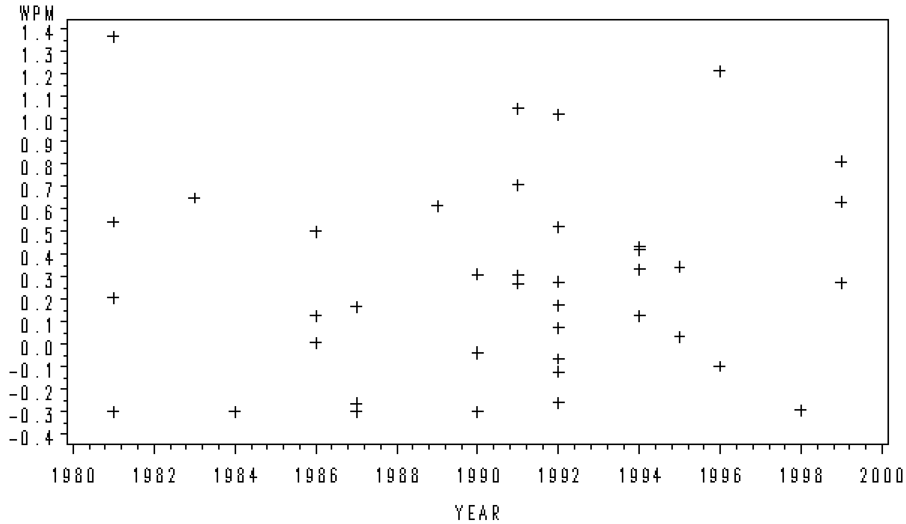

Figure 4: Trend Wetlands impacts (WPM) through Time. Values in vertical axis are log-transformed

4.2.4.4 Endangered species

Endangered species addressed showed a very significant increase as an effect of time but did not show an effect from classes.

Table 4.21 Significance of main effects of Time (year) and classes (pre and post 1993) on ES and

Effect	Num DF	Den DF	F Value	Pr > F
YEAR (random)	1	29	8.99	0.006**
CLASS	1	29	0.22	0.643

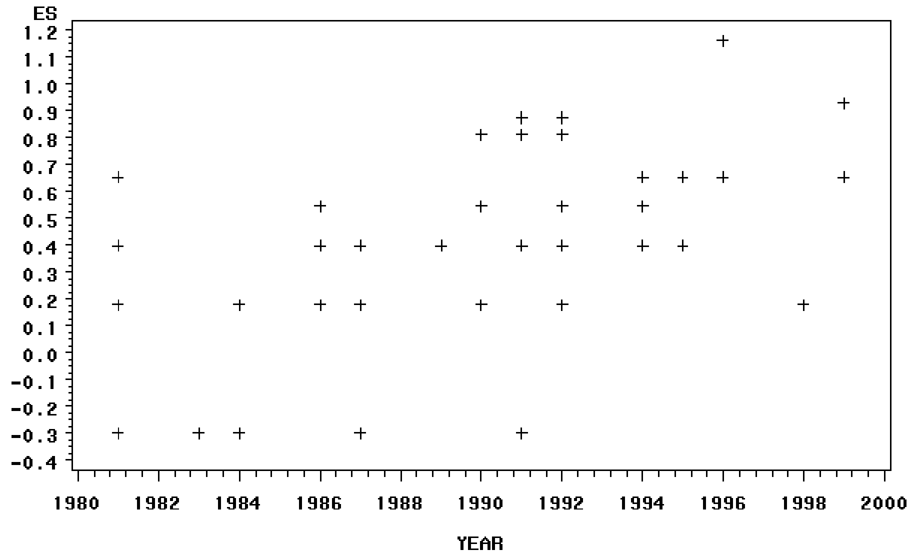

Figure 5: Trend Endangered Species addressed (ES) through Time. Values in vertical axis are log-transformed

4.2.4.5 Principal components

The effect of time in the number of endangered species addressed and forestlands, and the lack of effect of classes Pre 1993 and Post 1993 in each of the variables, suggest that classification was more related to geographic location and income differences. Because of that, the variables resulting from the PCA were also used for time trend analysis, in order to use fewer variables that could explain better the variability of the data and arrive to a better global interpretation than looking at individual variables behavior. In this case each principal component was labeled according to the general description of the dataset that they provide (see section 4.2). The first principal component describes the variation of EISs in function of income, cost of the project (CC and CRW) and impacts to property in the piedmont (RES). On the other hand, the second principal component describes the variation of EISs in function of impacts to natural resources (WPM, FPM) and related environmental assessment information in EIS (ES, FS, BIO, and CI). Thus, each PC was labeled as follows:

PC1 – Cost of project, income and impacts to property in the Piedmont

PC2 – Income, cost of construction and impacts to environmental resources

Table 4.22 shows that the first principal component had a very significant effect of time but not of classes.

Table 4.22 Significance of main effects of Time (year) and classes (pre and post 1993) on PC1

Effect	Num DF	Den DF	F Value	Pr > F
YEAR (random)	1	29	10.75	0.003**
CLASS	1	29	2.12	<0.156

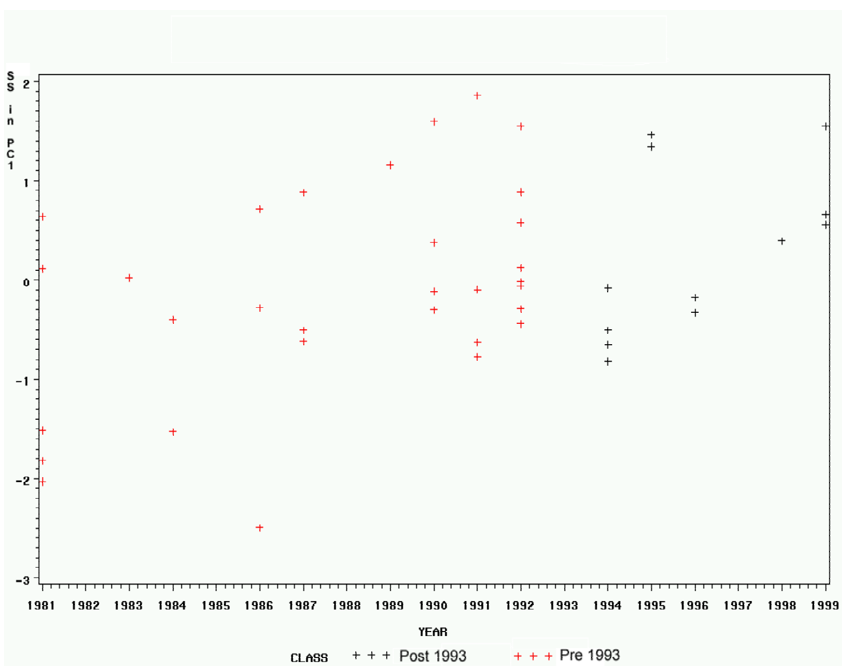

Figure 6: Trend Principal component 1 (Income, cost of project and impacts to property in the Piedmont) through Time. Axis shows standardized scores (SS) for each EIS in principal component.

On the other hand, Table 4.23 shows that either time or classes did not affect the second principal component. Although, when an outlier observation is extracted from the data[11], there is a very significant effect from time on this principal component.

Table 4.23 Significance of main effects of Time (year) and classes (pre and post 1993) on PC2

Effect	Num DF	Den DF	F Value	Pr > F
YEAR (random)	1	29	1.78	0.1920
CLASS	1	29	0.42	0.5216
YEAR* (random)	1	29	13.05	0.0012**

* Very significant when 1 outlier is extracted

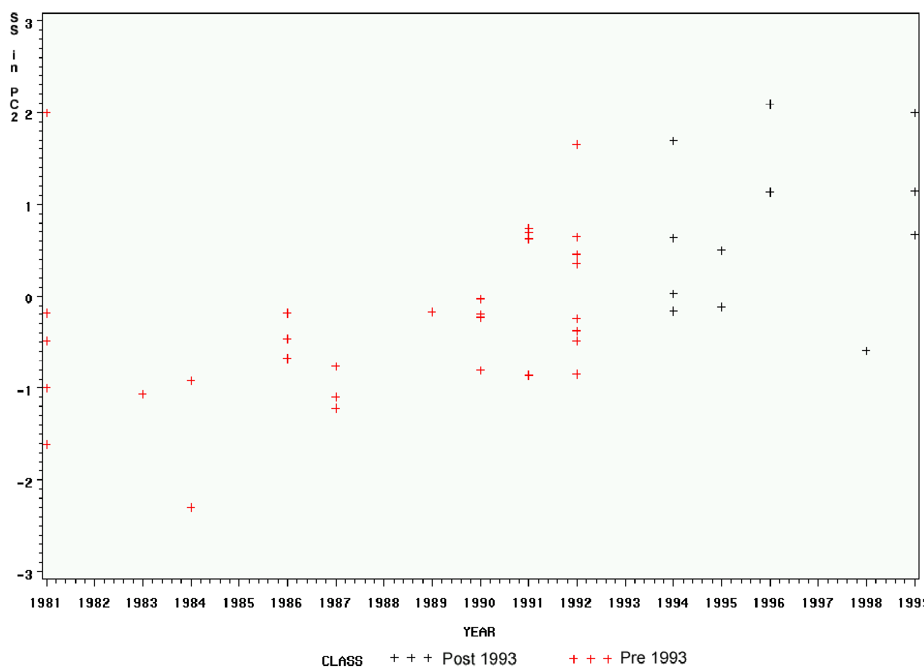

Figure 7: Trend Principal component 2 (Income and cost of construction and impacts to natural resources) through Time. Axis shows standardized scores (SS) for each EIS in principal component.

[11] EIS R-1023 of 1981, with extreme values in FS, FPM, and WPM, was considered an outlier.

The fact that PC1 (cost of project and impacts to property in the piedmont) only showed an effect from time suggest that EISs have changed from 1980 to 1999 with respect to this relationship, probably towards more expensive projects involving more impacts to residences. Likewise, the time trends in PC2 (physiography, income, cost of construction and impacts to environmental resources) suggests that the relationship among geographic location and impacts to natural resources is more evident as attention to environmental assessment components increased. This result, somehow, is contrasted by the low canonical correlation between environmental assessment and environmental impact variables. However geographical location and environmental impacts are correlated, and geographical location and environmental assessment are moderately correlated. This principal component must then reflect an overall characteristic of EISs regarding variables within these groups.

On the other hand, none of these relationships has been affected by the CEQ 1993.

5 DISCUSSION

5.1 Overview

This study attempts a quantitative examination of relationships among components of 43 environmental impact statements produced by NC DOT from 1980 to 1999 in order to find data patterns that allow us to qualify these studies. Examining NCDOT environmental impact statements during this period offers a few challenges.

First, the practice of environmental impact assessment was rapidly evolving during the early 1980s, following adoption and implementation of NEPA regulations. NCDOT, like all state transportation agencies, was following Federal Highway Administration (FHWA) guidance, presented through FHWA workshops and manuals that defined the federal agency's idiosyncratic process. FHWA guidelines had to be adapted to realities of state regulatory processes and data availability as they evolved in response to Environmental Protection Agency and other federal agency mandates and funding initiatives. Thus, practitioners producing NCDOT EISs were consistently aiming at moving targets in terms of expectations for completeness.

As a second challenge, each project for which an EIS is prepared occurs in a unique landscape with project specific characteristics. These characteristics include dimensions of the project, advocates and opponents of the project, flora and fauna native to the project area, level of development in the project area, and purpose and need for the project. Such purposes and needs range from creating a bypass around an urban area to upgrading a stretch of rural highway on new location for safety reasons. Such variability provides limited similarities upon which to make effective comparisons of the resulting EIS documents.

Third, the process of preparing EISs, while subject to general timetable and milestone expectations, varies greatly from project to project, depending on circumstances that arise while the studies and compilation of the document are under way. Changes in regulations and changes in characteristics of a project study area can equally affect the end product, the EIS.

Finally, the quality of an EIS is a perceived value. To some extent, then, effectiveness of the language used, style employed, amount of graphic support, clarity of connections within the document, and other factors of rhetorical impact add or detract from the perceived quality of an EIS. No acknowledged method exists for quantifying these matters and effects they have on perception of quality in the documents examined. This study specifically avoids examining the rhetorical devices and dimensions in evidence in EIS documents produced by NCDOT.

To produce a document of quality, authors of EISs need to collect accurate environmental data, which is expensive and time consuming. Recent development of applied environmental sciences has provided varying methods to make data collection a little more affordable. For instance, a record of the type of forests can give information of the species that would be affected if a project considers clearing these areas. The same can be said for wetlands. Data that can provide indirect information about other subjects and let us infer effects on them are called *indicators*. An environmental study involving a broad area, as a highway project, needs to collect selected indicators of the state of the environment. From these, we could get an accurate idea of the inventory of resources and their location in order to allow us to plan their modification or avoid impacts due to human activities.

In simple terms, an EIS is good when the information it provides is accurate and we can make informed decisions regarding the use of natural, human and/or economic resources. In this sense, lack of data or its inconsistency diminishes the quality of any document. For instance, in the EISs recorded, only few variables were complete or present in all the studies in such a way to allow complete comparisons among them[12]. Likewise, different classifications used to refer to the same resources, e.g. farmlands, water bodies, or forestlands, made detailed comparisons between studies difficult, as the data were too variable having different nomenclatures or being measured in different ways. An example of the mentioned fact are impacts to farmlands, which are divided in classes that usually overlap each other making the accounting and statistical process difficult and inaccurate.

On the other hand, it is important to bear in mind that use of quantitative data can hardly reflect the complete characteristics of a policy process, such as NEPA, without introducing some external input, be it quantitative or qualitative, which may involve subjective approach or better, sound experience. Despite that, it is expected that relationships among numerical data in EISs could let us learn about characteristics not only of the documents but of the process itself, trying to decrease the amount of subjective assumptions in order to identify those elements of EISs can let us measure their quality.

[12] See Appendix A for list of all variables recorded and section 3.3.1 for used variables description.

5.2 Economic factors, impacts on property, and quality of environmental information

This analysis provided two different ways to characterize EISs. The two descriptions involve economic characteristics of projects. The first involves mainly impacts to property and the second one involves impacts to natural resources. These are discussed below.

The first principal component analysis shows that four factors in EISs are related in the same direction and importance: income per capita, cost of right of way, cost of construction, residences relocated, and project location in the piedmont. Thus, there is a spectrum of projects from less expensive in terms of CRW and CC, with fewer impacts on residences, and more likely to be in CP, to more expensive, higher impact projects more likely to be in Piedmont. Thus, the positive coefficient for public comments in this first principal component suggests that public intervention in the EIS process is more prominent when impacts on properties are expected.

On the other hand, the second component shows a different relationship between economic and environmental factors. Income per capita and cost of construction are related in the same direction as impacts on natural resources (forests, wetlands, endangered species). This suggests that impacts on natural resources are more likely to be identified in areas with higher income per capita. The fact that wetlands and forests have to be filled or cleared might increase the cost of construction, but not necessarily the cost of the right of way, as these lands usually are less expensive than developed ground. However, potential impacts on endangered species could result from forest and wetland removal. This relationship also shows that public comments (used here as an indicator of public involvement in the EIS process) occur more often when residence relocations are predicted rather than when impacts to environmental resources such as wetlands or endangered species are, as supported by the first principal component. The second component also suggests that this relationship is more likely to characterize projects in the Coastal Plain (as opposed to the Piedmont).

The completion index (CI), an indicator of the amount of information included in each EIS, appears in both components, although it seems to be more important in the first component. This suggests that more information is collected when a project has more impacts on property than on natural resources. Note that the principal component analysis excludes the year of the study, or a time trend, that could also help explain variation among studies.

5.3 Relationship between Site & Project and Environmental impacts, and between Site & Project and Environmental Assessment

Canonical correlation analysis allowed identification of relationships among groups of variables that are usually present in EISs. The squared canonical correlation between the characteristics of the site and project and the environmental impacts found in the EIS suggests that environmental impacts (on wetlands, forests, and residences) are related to whether the project is in the piedmont or in the coastal plain. This geographical relationship was expected since more wetlands occur in the coastal plain than in the piedmont. Likewise, environmental impacts are also related to economic characteristics of the project, represented here as costs of both right of way and construction, and also income per capita. These correlations summarize the relationships suggested by the two principal components discussed above. The correlation between impacts and project costs cannot be attributed to size of the project because both cost of right of way and cost of construction were normalized by size of the project.

The relatively low correlation between the characteristics of the site and project and the environmental assessment (0.43) suggests that the decision to involve more specialists in the EIS is not strongly related to location of the proposed project or income level in the project region. Furthermore, public involvement, as measured by public comments, does not seem to be due to the regional or economic characteristic of a particular project but rather, as suggested above, due to impacts on private property.

On the other hand, the completion index might be related to economic characteristics of the project site, such as income per capita, which would be supported by the PCA discussed above. This might, on one hand, imply that counties with more economic resources can afford a more complete EIS and on the other hand suggest that a more complete EIS is required in counties with higher income per capita because people, institutions, and agencies in these regions expect more thorough EISs.

5.4 Relationship between environmental assessment and environmental impacts

The canonical correlation analysis showed little relationship between the process of environmental assessment and the environmental impacts identified. The fact that numbers of specialists, endangered species, and surveys had a positive correlation with the canonical coefficient for environmental impacts, and that public comments and completion of information showed a negative correlation instead has to be interpreted carefully.

In theory, one might expect a relationship between these two topics in the same direction, as environmental impacts are supposed to be estimated from the results of environmental assessment, or a particular methodology used to identify and quantify environmental impacts. In practice, however, it is desirable that methodologies should not affect the findings of environmental assessment. In this sense, it is a positive finding that environmental assessment and environmental impacts are not related.

One possible interpretation for this result is that public comments, which is an exogenous variable to assessment of environmental impacts on natural resources, added noise to the data. In the case of completion of information (CI), this variable might include more factors than those that affect biodiversity directly, such as environmental impacts to wetlands, forestlands and endangered species. The EIS dataset comes from a wide geographic and economic spectrum; to analyze more direct cause-effect relationships between environmental assessment methodologies and predicted environmental impacts might require focusing on projects occurring within a smaller geographic area.

5.5 Influence of CEQ 1993 biodiversity regulation on NC-DOT's EISs

This discussion is based on the results of the logistic discrimination analysis in order to find whether classes existed among the 43 EISs corresponding to CEQ 1993. The results suggest that there is a difference among EISs before 1993 and after 1993. This difference is explained principally by physiographic location (Piedmont or Coastal Plain), and secondly because of differences in number of endangered species addressed, income, and predicted impacts to wetlands.

The proportion of projects proposed in the Coastal Plain after 1993 was bigger than before 1993, and in counties with high income per capita. Controlling for these differences, we find that EISs after 1993 identify more endangered species assessed and fewer impacts to wetlands. However, this is not consistent with the actual data in the case of wetlands, as mentioned in section 4.2.3, or with the principal components and will be interpreted in the following subsection with results of the time trend test on this variable.

The results suggest that after 1993, NC-DOT focused in proposing more projects in the Coastal Plain. This might not be necessarily an expected effect of CEQ1993, but rather, from development plans. On the other hand, CEQ1993 may have had an impact on the practice of EIA in NC, especially in addressing more endangered species that could be impacted in EISs. This effect is expected as this variable is logically linked to biodiversity impacts.

On the other hand, and in spite of the inconsistency found, the presence of impacts to wetlands as a source of discrimination is important from an environmental assessment perspective. It is common knowledge among EIS practitioners that significant predicted impacts to wetlands and to endangered species can stop or delay a project from being approved under the NEPA process. It is interesting to find that the discrimination analysis reflected the importance of the factors that are crucial in the EIS process.

As income per capita in this study is an exogenous variable to the original EIS data, its importance in the separation of classes must be analyzed carefully, especially since it is not correlated to any of the above-mentioned variables (see partial correlations, Appendix D). However, it is very likely that it represents a characteristic of project location.

On the other hand, the fact that critical issues within EISs, such as endangered species and wetlands impacts were two of the main sources of differences between EISs before 1993 and after 1993, as supported by the logistic discrimination analysis, suggests that improvements or allocations of resources were more oriented to these critical issues in order to get EISs, and therefore the projects, approved.

5.6 Trends between environmental information in EISs and time

As was mentioned before, relationships among variables and among groups of variables did not consider time as a variable. The trend analysis was used to incorporate the time factor and infer whether it had influence in the variability of the data in EISs. The trend analysis suggests that the amount of environmental data incorporated into EISs is increasing through time; however this trend is not significant. This trend insignificance might suggest that the EIS process would be under a transitional period from lesser to higher improvement of information or quality. However it is important to consider the limited statistical power of tests due to small sample post-93.

On the other hand individual variables such as endangered species addressed and impacts to forestlands presented an increasing trend as an effect of time but not as an effect of regulation (CEQ 1993). This characteristic changes, though, when the characterizations given by the two principal components found were used as dependent variables in time trend analysis. As mentioned before, PC1 (income, general cost of project and impacts to property in the piedmont) showed only an effect from time, whereas PC2 (environmental assessment and impacts to natural resources in the Coastal Plain) was not affected significantly by either time or regulation. However, only when PC2 is treated for outliers it shows a very significant effect of time.

These results suggest a global overview of the evolution of EISs from 1980 to 1999. On one hand, the two mentioned important characteristics (or relationships) of EIS, or expressed in a more generic form, economic factors and environmental impacts in a project, had existed through time. On the other hand, none of these characteristics has been affected by regulation. As the relationship given by the PC1 (income, general cost of project and impacts to property in the piedmont) was only affected by time, we could infer that projects related to piedmont area involving impacts to property have become more expensive. This suggests that a regulation on biodiversity, such as CEQ1993, is unlikely to affect or change economic-impacts-to-property characteristics of projects.

In the case of PC2 (environmental assessment and impacts to natural resources in the Coastal Plain), an effect from time suggests that environmental impacts to natural resources, and environmental impact assessment factors have been increasing from 1980 to 1999, especially in the Coastal Plain. The lack of effect from CEQ1993, suggests, as in the case of the first component, that regulation alone could not affect an economic-environmental relationship.

It would be interesting to know to what extent in time regulations or legislation alone are able to improve or affect this environmental policy process. If assumptions based on the non-significant time trends and the very significant based on the two principal components are true, we would have to recognize that the CEQ1993 could not affect significantly the amount of environmental information in EISs or other factors related to environmental impact assessment. However CEQ 1993 could have affected the focus of NC-DOT as to where to target their next projects and the frequency at which they used to produce them, as there were not EISs published in 1993 and there were fewer produced after then.

It is still important, however, to identify the topics or issues that require more attention in the future if what we want to improve is the EIS process itself or, in the case of this research, treatment of biodiversity issues in a more detailed or advanced level, as some authors have suggested (Atkins et al. 2000).

5.7 Implications of results in EIS and predicted impacts

So far, the discussion has focused on each particular statistical analysis. In this section, we will discuss the implications of the overall results in EIS practice. It can be suggested that those who produce EISs have acquired knowledge about the NEPA process so that improvements to EISs will only occur in those topics or issues that either legislation or the administrative process itself identify as critical to improve. Consider, for example the low quality of information regarding farmlands, for which subcategories overlap each other frequently in EISs, as mentioned at the beginning of this chapter. As impacts to farmlands, and overall to developed lands are not considered an important issue to pass the process, then accuracy of this kind of information receives low priority.

Whether change in EISs through time suggests greater compliance may be related to the inclusion of additional technical information that has become important at either public, technical, institutional, or policy levels. It can be assumed that during the last 20 years, professionals dedicated to environmental assessment as well as federal agencies involved in the process have gained experience and that had helped to enhance the way EISs are currently produced in NC for highway projects, but only in a few selected topics, as the trend of information completeness and time was not significant.

However, improvement might reach a limit or an economic constraint with respect to what is legally required from an EIS. For example, current practice in North Carolina requires on-the-ground searches for federally listed endangered and threatened species if potential habitat exists in the study area. However, searches of potential habitat are not required for federal species of concern (FSC). Nor are searches required for state-listed protected species if they are not federally listed as endangered or threatened. Although conducting searches for FSC and state-listed species could explicitly improve the extent to which EISs address biodiversity questions, the time and costs involved are viewed as prohibitively expensive. Only in rare circumstances, such as when scientific judgment concerning a species is moving toward its being federally-listed, will such searches be conducted.

Clearly, the true success of an EIS can be calculated in the way it can forecast actual environmental impacts that occurred and can be measured in the field. This task has not been achieved yet, especially since details of road construction are not designed until after the EIS is approved. In that case, it is important to define what kind of technical information we need in practical terms from an EIS to forecast environmental impacts accurately and make development decisions upon them. Or do we need for EISs to overestimate the amount of environmental impacts so that the responsible agency, in this case NC DOT, commits to keep those impacts within reasonable and predicted limits? In any case, an EIS should serve as a guide to ensure that necessary development will happen with the least amount of environmental damage.

This issue becomes more critical when other topics such as treatment of indirect impacts of highway projects or its cumulative impacts are covered only generally. A more challenging task is to quantify environmental impacts of neighbor projects when in fact each EIS treats single projects. Use of environmental assessment and environmental management methods would facilitate environmental quality, not only in the documents but where it is more important, in the field. For this interdisciplinary coordination among project engineers, environmental consultants in the design of a project would make the EIS process more useful.

5.8 Limitations of use of information in EIS and of this study

Methods of environmental assessment have crucial importance in EISs as they help achieve high quality of technical information required to forecast environmental impacts. A bias against impacts to certain types of landscape may be revealed by the way in which landscape components are treated in EISs. For instance, information pertaining to farmland potentially impacted is reported inconsistently in NCDOT documents (as mentioned above) and cannot be used reliably for comparison purposes. Unlike impacts to forest and wetland, conversion of farmland to highway and other uses appears to generate little concern. This lack of concern seems to translate into tolerance for inconsistent terminology and unclear reporting of potential impacts to a less valued resource. It is likely that open farmlands are more highly valued in high-income counties.

However, the increasing use of Geographic Information Systems, for instance, for forest and wetland delineation and to estimate areas that will be impacted by a road project, has added accuracy and therefore quality to the process. GIS and other data inquiry systems, which depend on keeping databases accurate and updated, are as reliable as the information they are able to provide from their databases. A related critical case is obtaining accurate endangered species data. Such databases are costly to update, as they depend upon periodic field surveys, which are expensive. Official lists of federally listed endangered and threatened species, federal species of concern, candidates and state-protected species are provided by different agencies in the federal and state government.

A first step in impact assessment is to identify the species in a particular protection category in the area of the project. Federal or state agencies provide a list of threatened and endangered species based on the information they store in their databases, regardless of whether the information is current or not. This list would be taken as the official reference for scheduling and performing field surveys for EIS. Logically, use of old information can result in the EIS being less accurate, and decisions on environmental impacts of a project based upon them, unreliable. In sum, in order to achieve reliable EISs, allocation of funds should be directed to source database maintenance. However, such allocation is not the responsibility of agencies proposing projects.

As environmental impacts predicted by EISs may not have a direct correlation with, at least, the environmental assessment variables used (number of personnel assigned to surveys for endangered species, amount of surveys), quality of information in EIS may still need to be analyzed or measured with other methodologies. On the other hand, it would be less difficult to assess quality when reliable information is ensured by processes that involve a quality control on each step. Future methodologies should include feedback from the parties involved in the EIS production and review process, state agencies, CEQ, environmental subcontractors and counties' representatives.

5.9 Summary of recommendations

The following recommendations are extracted from the previous discussion and summarized below:

- NCDOT must provide consistent information in its future EISs, trying to standardize the variables or topics to cover in each project.

- It is important to acknowledge and make of public knowledge those issues that are crucial in the EIS process, regardless of the proposing agencies. This would help to center the attention of public or agencies to the main environmental impacts assessed and perhaps shorten the review process.
- Improve treatment of different topics in EIS by interdisciplinary collaboration. For instance, treatment of indirect or cumulative impacts could be improved by introducing, or adapting, best methodologies applied among agencies. This way, different federal agencies would learn from their own experience and documents could be more standard.
- Ensure that environmental impacts are treated with the same effort, regardless of level of income in the project area, cost of project or type of impacts (to natural resources or to human property).
- In order to analyze more specific issues within the EIS process, it is suggested to focus on smaller and similar geographical areas.
- In order to improve the treatment of impacts to endangered species, EISs should also include federal species of concern.
- In order to make the EIS process better understood by the different parties involved, it is suggested to include in the documents the updated EPA review criteria to grade EISs.
- The state government should ensure that all the federal agencies in NC get accurate information regarding the status of natural resources.

6 CONCLUSIONS

From 1980-1999, 43 environmental impact statements were completed for North Carolina by the Department of Transportation. Thirty projects occurred in the Piedmont province and nine occurred in the Coastal Plain, while only four occurred in the Mountain province.

The analyses performed with EISs from 1980 to 1999 suggest that predicted environmental impacts in EISs, such as forest and wetland impacts, are related to the particular physiographic region where a project was built (Coastal Plain or Piedmont). Impacts are also related to economic factors such as income per capita and the costs of right of way and of construction. While a relationship between geographical region and environmental impacts was expected, the relationship between environmental impacts and economic characteristics of a project was not. This relationship suggests that more environmental impacts occurred or are identified in high-income counties, and public involvement in the EIS process tends to occur more when impacts to property are identified. However, information pertaining to farmland potentially impacted is reported inconsistently in NCDOT documents and cannot be used reliably for comparison purposes. For this reason, environmental impacts in lower-income counties may be seriously underestimated.

The characteristics of environmental assessment were not statistically significantly related to important environmental impacts such as impacts to wetlands, forestlands, and residential relocations. This lack of significance seems to indicate that regardless of the number of specialists involved, or the number of field surveys, the EIS process identifies similar impacts, determined by type of project and site. Site and project information and environmental assessment characteristics showed a moderate correlation statistically significant.

A main difference between EISs before and after the CEQ regulation of 1993 is of physiographic region of projects. Assuming they effectively represent biodiversity treatment in EISs, the logistic discrimination provides some evidence that the CEQ regulation of 1993 had an effect on in environmental impacts treatment. This effect might suggest either an improvement in data quality and/or an increase in the attention given to endangered species in the coastal plain included in EISs because of demands from the regulation.

On the other hand, two significant time trends of relationships between economic factors of EIS projects and their predicted impacts to property and of geographical location, environmental impacts and environmental assessment factors were found in this study. This relationship characterizes EISs during all the study period, however it has not been affected by environmental regulation.

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APPENDICES

APPENDIX A
List of variables collected from each DOT-EIS

a. **Project information**

- ***Type of project*** **refers to whether the project is an improvement to a highway (or road) a new highway.**
- *Number of State Project* is the number assigned by the North Carolina Department of Transportation to each project.
- *Code* is an internal codification that usually is characterized by an “R” for rural or “U” for urban followed by four digits.
- *Right of way* is the width that includes the width of a projected road and an additional margin of space in case changes in design are required.
- *Study corridor width* is the width of the area of survey for a proposed project. It is supposed to be wider than the right of way’s width, as it is intended to explore the immediate environmental impacts of the project within this area.
- *Study corridor length* is the length of the area of survey for a proposed project. It is supposed to be longer than the right of way length.
- ***Length of preferred alternative*** **is the length of the designed road project that is denoted in the EIS as the preferred option to build.**
- *Number of lanes* is the total number of rows that a road is designed to have, regardless of the direction of transit.
- *Minimum design speed* is the minimum speed at which transit in one road is designed.
- ***Cost of right of way*** **is the cost of acquisition of land property within the right of way area of a designed road.**
- ***Cost of construction*** **is related to the cost of workforce, materials, and engineering, in the building of a road.**

- *Cost of mitigation* refers to the cost of all the measures oriented to restore ecologic functions and structure, usually of wetlands, that road construction may have deteriorated.
- *Cost of project* is the sum of the costs of right of way, construction, and mitigation.
- *Number of general alternatives including "no building alternative'* refers to the number of alternatives considered in the environmental study and their impacts. These usually are: mass transportation, improvements to existent roads, building a new road, management updates to roads, and doing nothing.
- *Number of sub alternatives* is the number of options considered only in the alternative of building new roads.
- Income per capita, these data was not collected from the studies but

b. Environmental site information

- *County(ies)* refers to the counties where the project will be constructed.
- ***Physiographic province* refers to the principal physiographic provinces in North Carolina where the project can occur: Blue Ridge, Piedmont, and Coastal Plain.**
- *Population by census tract* is the amount of population according to census data that is located within the area of influence of the project, usually referred to as census tract.

c. Environmental assessment information

- ***Number of specialists in the team* is the number of professionals involved in the process of preparing the environmental impact assessment study.**
- ***Number of endangered and threatened species addressed in the report* refers to the number of species mentioned with a designated federal conservation category, such as threatened or endangered species in the State where the project is being proposed.**

- *Number of plant species assessed by project* is the amount of plants surveyed from the group of endangered and threatened species addressed in the report.
- *Number of animal species assessed by project* is the amount of animal species surveyed from the group of endangered and threatened species addressed in the report.
- ***Number of surveys conducted for Threatened and Endangered species in the assessment* refers to the number of field studies oriented to find evidence that suggests the presence of endangered or threatened species in the area of influence of the proposed project or study corridor.**
- ***Area of wetland impacted by a selected alternative* refers to the estimated area of wetland that will be modified, partially or entirely, because of the construction of the road. It is usually estimated by overlapping the right of way area over a wetlands map.**
- *Stream impacts* is the estimated length of streams, creeks, rivers, that will be crossed by the construction of the road.
- *Number of hazardous material sites* refers to the amount of sites that contain hazardous materials to the environment that exist within the proposed project.
- *Evaluation of social impacts* refers to whether or not the study has considered potential impacts to social elements of the area because of the road's construction.
- *Number of conservation areas affected* is the number of sites with some kind of local, state, or federal protection designation (such as state parks, national parks, archeological sites, etc.) that can be impacted by the project (e.g. a section of a road going through a National Park).
- *Area of farmlands impacted* is the area of farmlands that are within the extension of the right of way.

- ***Number of residents relocated by project* refers to the number of residence properties that are located within the right of way of the projected road and need to be relocated to allow the road construction.**
- ***Number of business relocated by project* refers to the number of business properties that are located within the right of way of the projected road and need to be relocated to allow the road construction.**
- ***Number of non-profit organizations relocated by project* refers to the number of non-profit organizations properties that are located within the right of way of the projected road and need to be relocated.**
- *Public participation* refers to the number of comments received by the agency in charge of the EIS by general public attendants to information meetings, as accounted by the same agency.
- *Evaluation of indirect and cumulative impacts* relates to whether identification of indirect and cumulative impacts has been considered in the study area. Indirect impacts are secondary effects on the environment of a road construction (e.g. loss of wetland is a direct impact and a secondary effect is the reduction of number of migrant birds in the area.) A cumulative impact is the overall effect of small impacts on the environment (e.g. loss of small green areas in a urban area may decrease the level of air quality.)
- *Study of mitigation* refers to whether or not plans for reverting the negative effects of road construction on the environment have been considered and included in the study.

d. Agencies participation

- *Number of proponent agencies* is the number of federal agencies that are submitting the project for review.
- *Proponent* is(are) the agency(ies) that assume(s) the leadership and administrative responsibilities of the EIS preparation under the National Environmental Policy Act.

- *Number of comments from agencies* refers to the number of letters and interoffice communications, in which relevant issues of the EIS are highlighted for further analyses.
- *Year of submission* is the year the draft EIS is sent for review to the Committee of Environmental Quality for evaluation.

Different denominations of Farmlands in EIS

Farmland Denomination	EISs from 1980 to 1999 including denomination
Agricultural/cleared land	28
State and locally important farmlands	19
Prime farmlands	32
Farmland	35

APPENDIX B

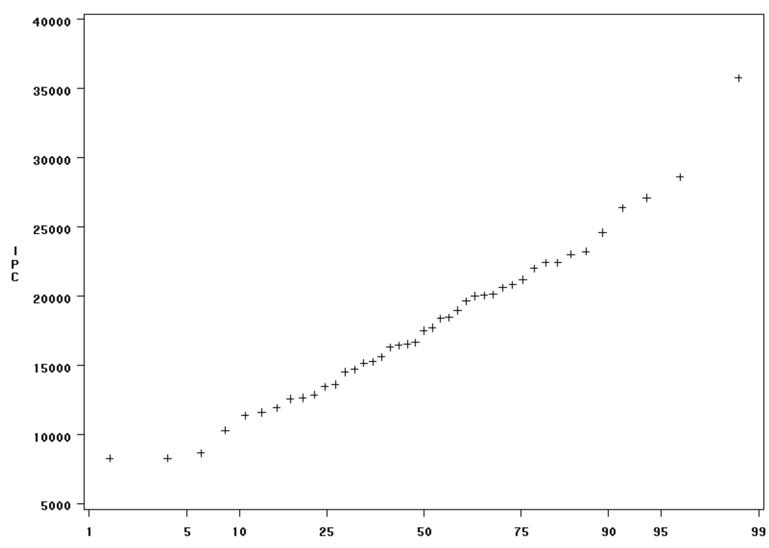
Data Normalization Method

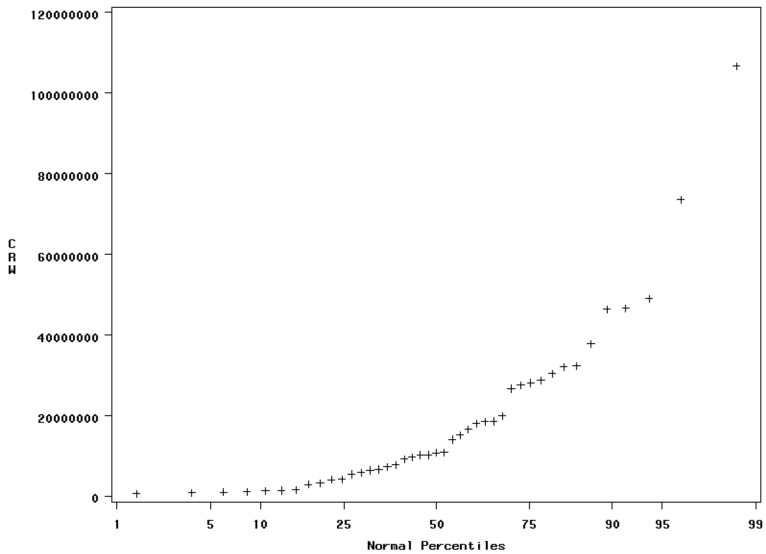
The normalization method used is shown next to each variable:

Variable(s)	Distribution	Normalization method
Cost of Right of Way/mile Cost of Construction/mile	Exponential	Square root SQRT(Var*)
Specialist per Study, Endangered species Field surveys	Logarithmic Exponential	Logarithmic Log (Var*) + 0.5
Acres of forestland impacted per mile Acres of wetland impacted per mile	Logarithmic Logarithmic	Logarithmic Log (Var*) + 0.5
Acres of residential relocations per mile of project Acres of businesses relocations per mile of project Acres of non-profit organizations relocations per mile of project	Logarithmic Logarithmic Logarithmic	Logarithmic Log (Var*) + 0.5

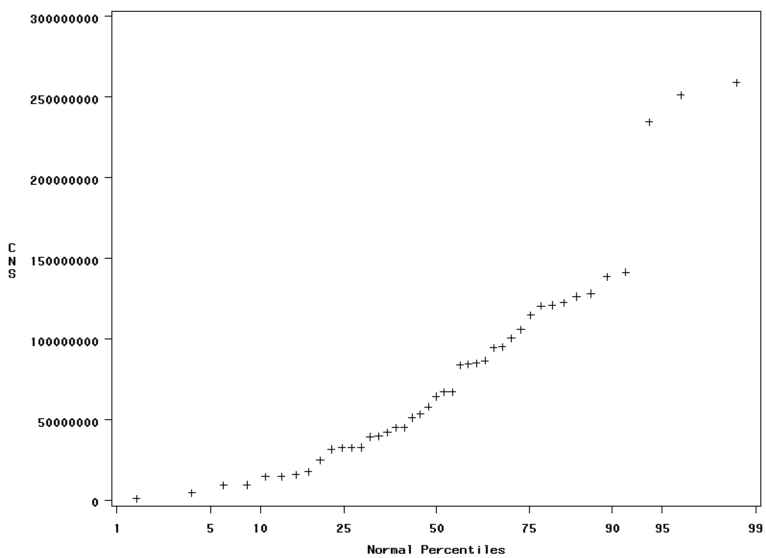
* Variable

Original Data Distributions





120000000
100000000
80000000
60000000
40000000
20000000
0
CRW
1
5
10
25
50
75
90
95
99
Normal Percentiles



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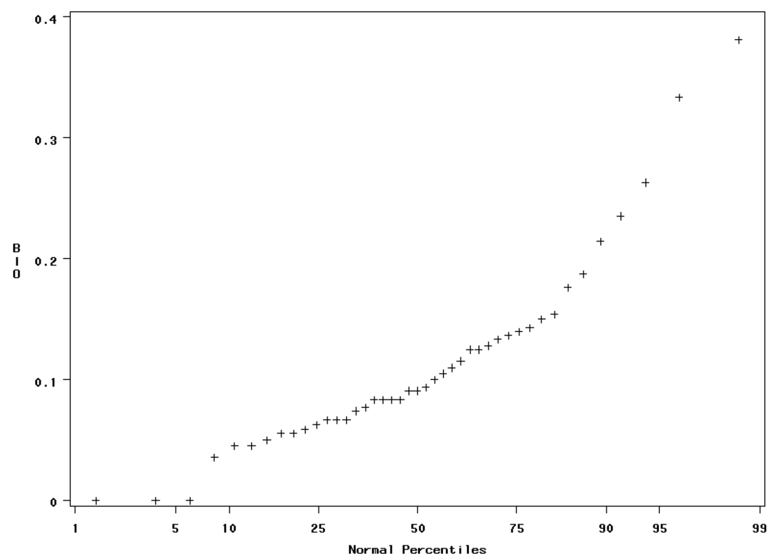
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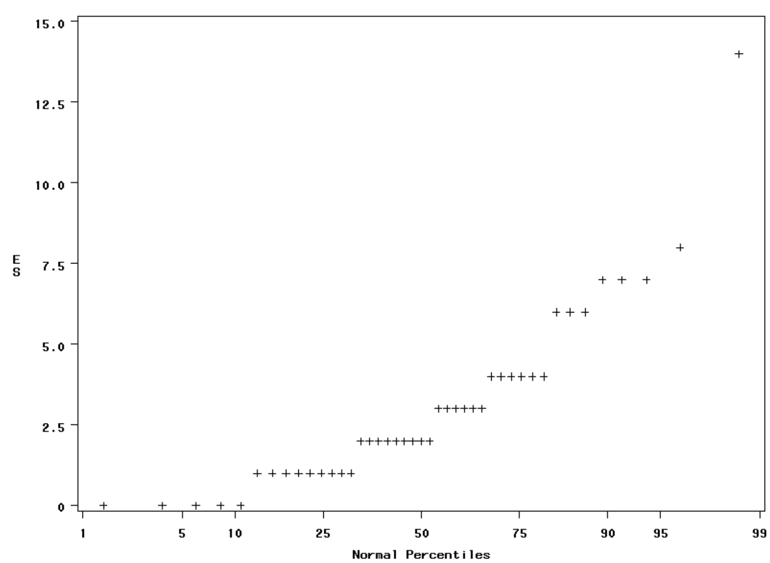
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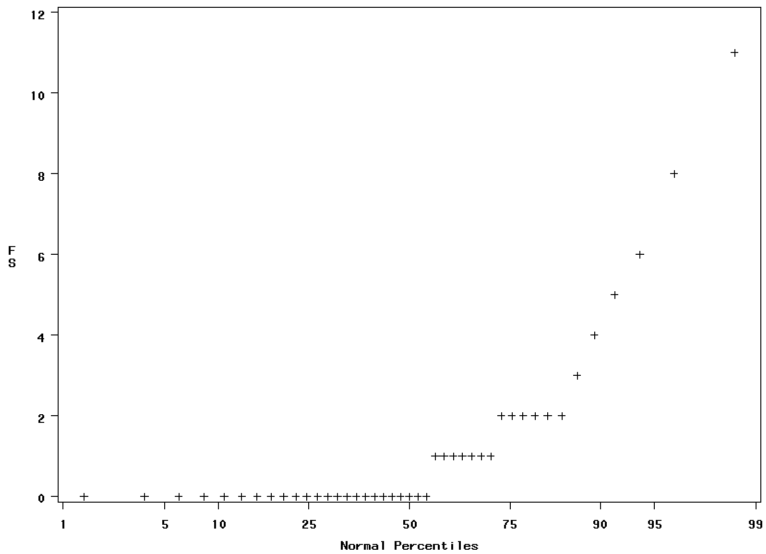

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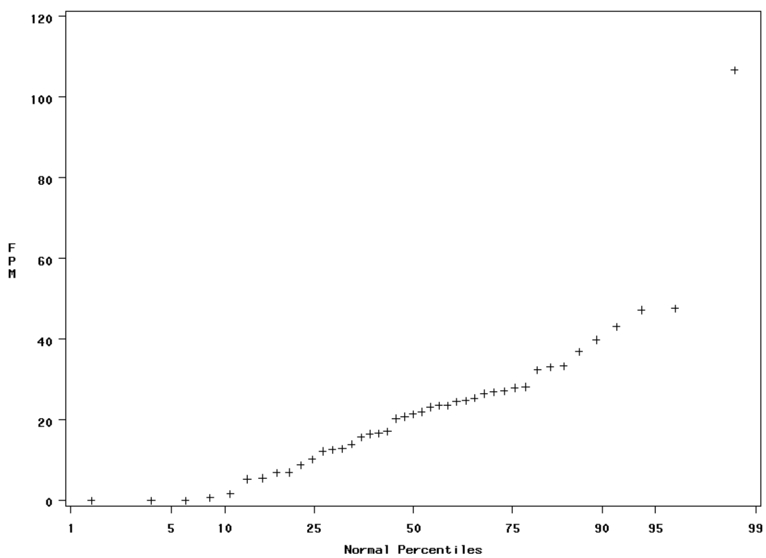

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F
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M
1
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10
25
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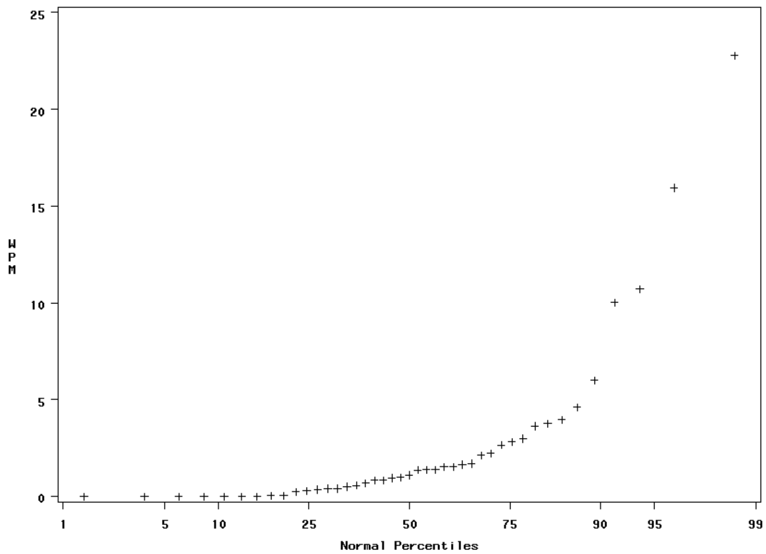
95
99
Normal Percentiles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20
15
10
5
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WPM
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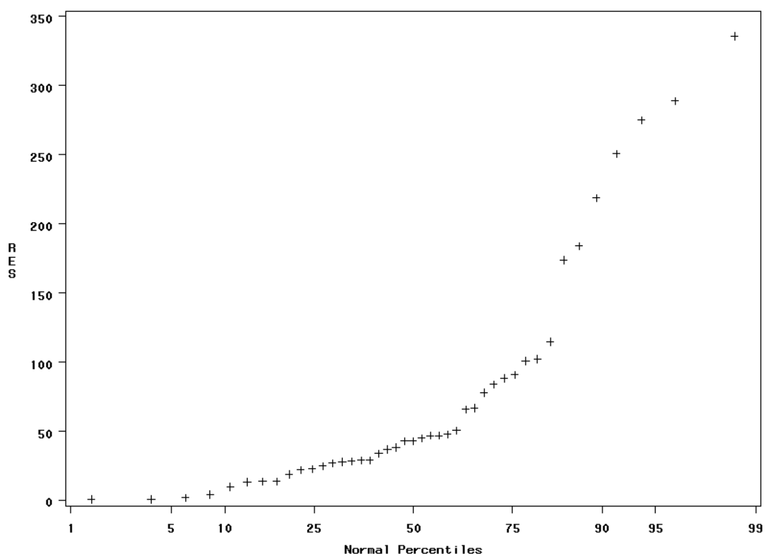
5
10
25
50
75
90
95
99
Normal Percentiles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10
25
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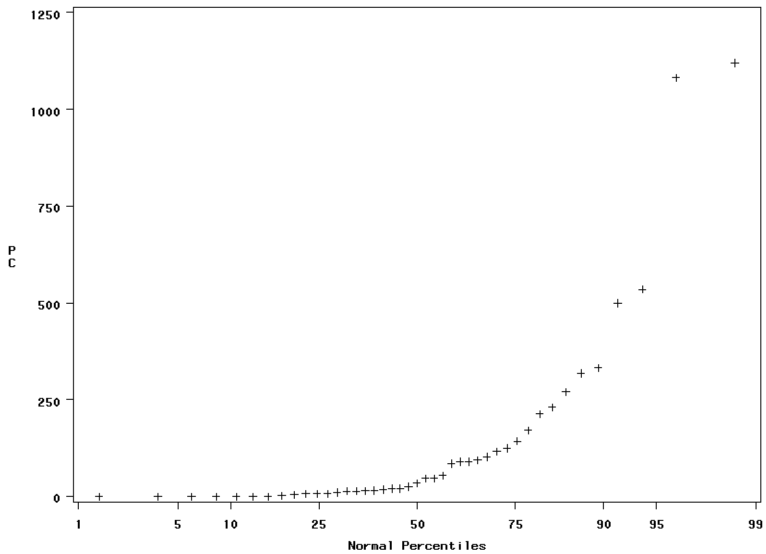
Normal Percentiles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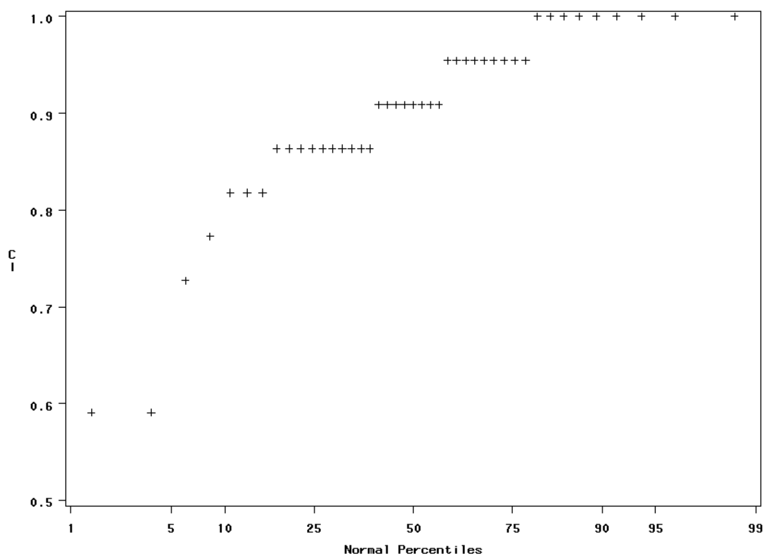
99
Normal Percentiles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0.8
C
I
0.7
0.6
0.5
1
5
10
25
50
75
90
95
99
Normal Percentiles

APPENDIX C
Principal Components Analysis

Observations	43
Variables	12

Eigenvalues of the Correlation Matrix				
	Eigenvalue	Difference	Proportion	Cumulative
1	3.09738379	0.32446262	0.2581	0.2581
2	2.77292116	1.49315312	0.2311	0.4892
3	1.27976805	0.28199564	0.1066	0.5958
4	0.99777241	0.06295196	0.0831	0.679
5	0.93482045	0.10921659	0.0779	0.7569
6	0.82560386	0.24680412	0.0688	0.8257
7	0.57879975	0.14488834	0.0482	0.8739
8	0.43391141	0.04774069	0.0362	0.9101
9	0.38617072	0.0846004	0.0322	0.9423
10	0.30157032	0.05502973	0.0251	0.9674
11	0.24654059	0.10180309	0.0205	0.9879
12	0.1447375		0.0121	1

Eigenvectors												
	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6	Prin7	Prin8	Prin9	Prin10	Prin11	Prin12
CP	-0.273	0.340	0.456	0.086	0.087	-0.126	-0.152	-0.255	0.218	0.235	0.466	0.403
IPC	0.391	0.210	-0.238	0.216	0.057	-0.242	-0.130	-0.567	-0.083	0.468	-0.223	-0.155
CRW	0.488	-0.012	0.151	-0.067	0.061	-0.326	-0.155	0.230	0.107	-0.182	-0.354	0.614
CNS	0.443	0.130	0.024	-0.228	0.262	-0.256	0.210	-0.115	-0.194	-0.399	0.548	-0.214
BIO	-0.053	0.374	-0.500	0.045	0.034	-0.295	-0.165	0.589	0.184	0.226	0.227	-0.079
ES	0.021	0.467	-0.228	-0.142	-0.030	0.332	-0.040	-0.268	0.558	-0.429	-0.171	-0.020
FS	-0.137	0.402	0.053	0.327	0.125	-0.074	0.759	0.094	-0.166	-0.025	-0.246	0.123
FPM	0.249	0.232	0.120	-0.635	-0.052	0.398	0.193	0.146	-0.104	0.481	-0.018	0.069
WPM	-0.073	0.416	0.475	0.002	0.132	-0.036	-0.411	0.192	-0.275	-0.138	-0.306	-0.428
RES	0.369	-0.112	0.400	0.282	-0.296	-0.012	0.205	0.192	0.532	0.143	0.075	-0.368
PC	0.205	-0.112	-0.022	0.353	0.718	0.501	-0.107	0.145	0.065	0.090	0.080	0.055
CI	0.266	0.228	-0.075	0.391	-0.526	0.375	-0.164	0.065	-0.387	-0.137	0.244	0.207

APPENDIX D

Partial Correlations Matrix

Variables													
PID	1.000												
CP	-0.716	1.000											
IPC	0.326	-0.157	1.000										
CRW	0.339	-0.323	0.524	1.000									
CC	0.206	-0.210	0.558	0.686	1.000								
BIO	-0.070	0.146	0.260	-0.069	0.049	1.000							
ES	-0.357	0.270	0.270	-0.073	0.141	0.475	1.000						
FS	-0.331	0.458	0.077	-0.237	-0.003	0.365	0.375	1.000					
FPM	-0.039	-0.027	0.201	0.298	0.438	0.038	0.376	0.020	1.000				
WPM	-0.385	0.668	0.024	0.026	0.053	0.199	0.341	0.401	0.219	1.000			
RES	0.275	-0.180	0.252	0.582	0.324	-0.341	-0.206	-0.144	0.136	-0.082	1.000		
PC	0.199	-0.237	0.181	0.211	0.203	-0.157	-0.073	-0.094	-0.003	-0.096	0.169	1.000	
CI	0.193	-0.097	0.432	0.233	0.197	0.157	0.317	0.125	0.224	0.143	0.341	0.048	1.000
	PID	CP	IPC	CRW	CC	BIO	ES	FS	FPM	WPM	RES	PC	CI

R^2

APPENDIX E
Data for Principal Components and Canonical Correlations

CODE	CLASS	YEAR	R	U	PID	CP	BR	IPC	IPC1	CRW
R-98	BEFORE	81	1	0	1	0	0	8.673	-0.6984286	1.2211585
U-301	BEFORE	81	0	1	1	0	0	11.39704	2.025611	5.6570395
U-203	BEFORE	81	0	1	1	0	0	11.634	2.2625714	3.3166248
R-1023	BEFORE	81	1	0	0	1	0	8.308	-1.0634286	2.0272121
R-1022	BEFORE	81	1	0	0	1	0	8.308	-1.382	1.2821215
U-510,U-608	BEFORE	83	0	1	1	0	0	12.592	10.345508	3.4354224
R-401	BEFORE	84	1	0	0	0	1	11.93408	0.5666736	2.7229983
U-507	BEFORE	84	0	1	1	0	0	14.723	3.355594	2.6098757
R-606	BEFORE	86	1	0	0	1	0	10.325877	-3.0912885	0.980702
R-609	BEFORE	86	1	0	1	0	0	15.184661	1.7674954	3.8124643
U-2011	BEFORE	86	0	1	1	0	0	16.567	3.1498343	2.6537245
R-1016&1017	BEFORE	87	1	0	1	0	0	13.457012	-0.4778131	2.2667895
R-2123	BEFORE	87	1	0	1	0	0	18.416	4.4811751	4.3539736
R-523	BEFORE	87	1	0	1	0	0	12.893316	-1.0415093	2.2897008
R-2000	BEFORE	89	1	0	1	0	0	20.145791	5.4051496	6.2543481
R-2219	BEFORE	90	1	0	1	0	0	17.752	2.8190679	2.9049978
R-2248B	BEFORE	90	1	0	1	0	0	22.439	7.5060679	4.3444056
R-2119	BEFORE	90	1	0	0	0	1	12.678	-2.2549321	3.0105731
R-2248A	BEFORE	90	1	0	1	0	0	22.439	7.5060679	6.1370318
R-2301	BEFORE	91	1	0	0	1	0	15.266	-0.0155451	2.7268106
R-2231	BEFORE	91	1	0	1	0	0	13.640294	-1.6412511	1.6290621
U-2524	BEFORE	91	0	1	1	0	0	20.855	5.5734549	7.0278092
R-0210	BEFORE	91	1	0	1	0	0	18.985952	3.7044066	2.3596293
R-529 B	BEFORE	92	1	0	0	0	1	14.539	-1.6367679	3.2788505
X-2D	BEFORE	92	0	1	0	1	0	16.451	0.2752321	4.4071976
R-1030	BEFORE	92	1	0	1	0	0	15.608014	-0.5677538	2.6279211
U-2307	BEFORE	92	0	1	1	0	0	19.647	3.4712321	3.137297
R-2239BC	BEFORE	92	1	0	1	0	0	16.332785	0.1570168	2.9351857
A-10	BEFORE	92	1	0	0	0	1	18.475619	2.2998511	2.0101598
I-2402	BEFORE	92	1	0	1	0	0	22.014	5.8382321	3.9004322
R-2247	BEFORE	92	1	0	1	0	0	23.042	6.8662321	5.3172125
R-2303	AFTER	94	1	0	0	1	0	17.54551	0.4549781	2.1442665
R-2554	AFTER	94	1	0	0	1	0	16.664009	-0.4265228	2.829502
R-2206	AFTER	94	1	0	1	0	0	20.079244	2.9887126	2.9485957
R-2552	AFTER	94	1	0	1	1	0	24.633427	7.5428953	2.1015139
U-2579	AFTER	95	0	1	1	0	0	26.401	9.1788669	4.5958518
R-2547/R-2641	AFTER	95	1	0	1	0	0	27.126	9.9038669	4.9308109
R-2633 AB	AFTER	96	1	0	0	1	0	21.227796	3.7172241	2.880631
U-2110	AFTER	96	0	1	1	0	0	28.617	11.106428	3.2439743
R-2707	AFTER	98	1	0	1	0	0	20.633	0.8042219	3.0605957
U-2519 AND X-2	AFTER	99	0	1	0	1	0	23.249223	3.0787047	4.0430269
R-2501	AFTER	99	1	0	1	0	0	20.032	-0.1385179	3.4703375
R-2635	AFTER	99	1	0	1	0	0	35.759	15.588482	5.1162662

CODE	CNS	BIO	ES	FS	FPM	WPM
R-98	6.3071944	-0.2218487	0.1760913	0.1760913	-0.30103	-0.30103
U-301	8.4053492	-0.1962946	0.6532125	-0.30103	1.3817449	0.20656
U-203	6.9282032	-0.2340832	-0.30103	-0.30103	1.1172713	-0.30103
R-1023	4.4874254	-0.0791812	0.39794	1.0606978	1.2477716	1.3667427
R-1022	4.4874254	-0.2466723	0.1760913	-0.30103	0.333486	0.544068
U-510,U-608	6.974797	-0.30103	-0.30103	-0.30103	1.3803463	0.650322
R-401	4.648439	-0.2284793	0.1760913	0.1760913	0.7659168	-0.30103
U-507	3.4774694	-0.30103	-0.30103	-0.30103	-0.30103	-0.30103
R-606	4.1366642	-0.1845244	0.39794	-0.30103	0.8650914	0.499921
R-609	7.824901	-0.2552725	0.544068	-0.30103	1.5726864	0.1296339
U-2011	9.1751864	-0.2632414	0.1760913	0.6532125	1.2311081	0.0070783
R-1016&1017	4.8538464	-0.2340832	0.1760913	-0.30103	0.8766828	-0.30103
R-2123	11.380119	-0.2710668	-0.30103	-0.30103	1.5165354	0.1673173
R-523	6.0374176	-0.2388821	0.39794	-0.30103	1.4321131	-0.2616733
R-2000	9.5937877	-0.2632414	0.39794	-0.30103	1.4383482	0.6167236
R-2219	5.1892764	-0.1697511	0.544068	-0.30103	1.341818	-0.0354421
R-2248B	8.6888111	-0.2263964	0.1760913	-0.30103	-0.30103	0.3117539
R-2119	7.6960818	-0.1983677	0.8129134	-0.30103	1.6788294	-0.30103
R-2248A	9.6254089	-0.2108534	0.544068	-0.30103	1.6391329	-0.0403432
R-2301	6.8124879	-0.2527253	0.39794	0.1760913	1.3745769	1.0503881
R-2231	5.9899884	-0.2018985	0.8750613	0.39794	1.3528968	0.3063588
U-2524	8.9999871	-0.2498775	-0.30103	-0.30103	1.2334391	0.2716389
R-0210	5.1683252	-0.2284793	0.8129134	0.39794	1.2103054	0.7075004
R-529 B	6.2728781	-0.2180558	0.8129134	-0.30103	1.1269764	-0.0623133
X-2D	7.8073338	-0.2410321	0.8750613	0.7403627	1.4133681	1.0217702
R-1030	4.9342141	-0.2340832	0.544068	-0.30103	1.1600044	0.5209002
U-2307	5.7610999	-0.2340832	0.1760913	-0.30103	0.9715851	-0.2612194
R-2239BC	5.8852312	-0.2146702	0.1760913	-0.30103	1.3293265	0.1763452
A-10	9.7564513	-0.20412	0.8750613	0.1760913	2.0303503	-0.1217379
I-2402	9.0514578	-0.146128	0.544068	-0.30103	1.4030647	0.2783818
R-2247	8.9442166	-0.20412	0.39794	0.544068	1.5268716	0.076146
R-2303	5.5468503	-0.2552725	0.544068	0.39794	1.1055102	0.4190243
R-2554	6.4031899	-0.2466723	0.39794	0.1760913	0.7836837	0.3332147
R-2206	6.4207929	-0.30103	0.39794	0.1760913	1.682765	0.1272638
R-2552	7.3607655	-0.1335389	0.6532125	0.39794	1.4548449	0.4347369
U-2579	9.5859768	-0.2596373	0.39794	-0.30103	1.4409268	0.0321266
R-2547/R-2641	9.3021368	-0.1870866	0.6532125	-0.30103	1.530025	0.3451063
R-2633 AB	8.4707238	-0.1941358	1.161368	0.39794	1.3197053	1.2160859
U-2110	7.7552786	-0.0550476	0.6532125	0.8129134	0.0819041	-0.0958869
R-2707	6.4198444	-0.2466723	0.1760913	0.39794	1.0305193	-0.293652
U-2519 AND X-2	9.0899257	-0.1918855	0.9294189	0.9294189	1.458292	0.812207
R-2501	8.2773355	-0.1173856	0.6532125	0.1760913	1.6060544	0.6317898
R-2635	8.247351	-0.1627273	0.6532125	-0.30103	1.3986273	0.2754093

CODE	RES	BUS	NP	FRM	PC	QIX	CI
R-98	0.2263964	0	0	0	0.39794	0.8666667	0.9090909
U-301	0.8763946	0	0	0.6532125	1.3324385	0.8444444	0.8636364
U-203	1.4065402	0	0	-0.30103	0.8750613	0.8444444	0.8181818
R-1023	0.3834218	0	0	-0.30103	-0.30103	0.8	0.8636364
R-1022	0.3834218	0	0	-0.30103	1.2174839	0.7777778	0.8636364
U-510,U-608	0.5779032	0	0	-0.30103	2.0149403	0.8666667	0.9090909
R-401	-0.0248236	0	0	-0.30103	-0.30103	0.7777778	0.7272727
U-507	1.462398	0	0	-0.30103	2.0663259	0.8888889	0.9090909
R-606	-0.217253	0	0	-0.30103	1.161368	0.7111111	0.5909091
R-609	1.1414952	0	0	-0.30103	1.9566486	0.8666667	0.9090909
U-2011	0.7155718	0	0	-0.30103	1.9754318	0.7333333	0.5909091
R-1016&1017	0.4607308	0	0	-0.30103	2.3626709	0.8666667	0.8636364
R-2123	0.4393327	0	0	-0.30103	2.7287595	0.8222222	0.7727273
R-523	0.4394596	0	0	-0.30103	0.9294189	0.8444444	0.8636364
R-2000	0.5259698	0	0	-0.30103	2.0986437	0.8666667	0.8636364
R-2219	0.4320198	0	0	-0.30103	1.7363965	0.8444444	0.8636364
R-2248B	0.8148741	0	0	-0.30103	1.5502284	0.8666667	0.8636364
R-2119	0.5247986	0	0	-0.30103	-0.30103	0.8666667	0.9090909
R-2248A	0.9900809	0	0	-0.30103	2.3314273	0.8666667	0.8636364
R-2301	0.5145191	0	0	-0.30103	0.8750613	0.8444444	0.8636364
R-2231	0.3598589	0	0	-0.30103	1.161368	0.9333333	1
U-2524	1.3626773	0	0	-0.30103	1.9319661	0.9555556	1
R-0210	0.6047217	0	0	-0.30103	3.0344279	0.9333333	1
R-529 B	0.7120994	0	0	-0.30103	2.4321673	0.8222222	0.8181818
X-2D	1.1047495	0	0	-0.30103	-0.30103	0.8666667	0.9545455
R-1030	0.4284293	0	0	-0.30103	1.9566486	0.8888889	0.9090909
U-2307	0.8303748	0	0	-0.30103	1.0606978	0.9111111	0.9545455
R-2239BC	0.3357921	0	0	-0.30103	0.7403627	0.8888889	0.9545455
A-10	0.3892078	0	0	-0.30103	2.5230958	0.9555556	1
I-2402	0.5450757	0	0	-0.30103	2.2342641	0.9333333	1
R-2247	1.2344429	0	0	-0.30103	2.6994041	0.9333333	1
R-2303	0.438731	0	0	-0.30103	1.6766936	0.9111111	0.9545455
R-2554	0.7288219	0	0	-0.30103	2.1568519	0.8222222	0.8181818
R-2206	0.5560804	0	0	-0.30103	-0.30103	0.8666667	0.9090909
R-2552	0.4655394	0	0	-0.30103	-0.30103	0.8888889	0.9545455
U-2579	1.285591	0	0	0.30103	-0.30103	0.9555556	1
R-2547/R-2641	0.8129134	0	0	-0.30103	1.3324385	0.8888889	0.9545455
R-2633 AB	0.4879521	0	0	-0.30103	1.4232459	0.9111111	0.9545455
U-2110	-0.161983	0	0	-0.30103	1.6766936	0.8888889	0.9090909
R-2707	0.8827266	0	0	-0.30103	3.0494119	0.9333333	0.9545455
U-2519 AND X-2	1.0078799	0	0	-0.30103	2.5044709	0.9777778	1
R-2501	0.8048398	0	0	0.1760913	1.1903317	1	1
R-2635	0.8634192	0	0	-0.30103	1.2671717	0.9333333	0.9545455

APPENDIX F
Data for Logistic Discrimination

CODE	CLASS	YEAR	TA	R	U	PP	PID	CP	BR	IPC	IPC1	CRW
R-98	0	81.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	8.67	-0.70	1.49
U-301	0	81.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	11.40	2.03	32.00
U-203	0	81.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	11.63	2.26	11.00
R-1023	0	81.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	8.31	-1.06	4.11
R-1022	0	81.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	8.31	-1.38	1.64
U-510,U-608	0	83.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	12.59	10.35	11.80
R-401	0	84.00	0.00	1.00	0.00	3.00	0.00	0.00	1.00	11.93	0.57	7.41
U-507	0	84.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	14.72	3.36	6.81
R-606	0	86.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	10.33	-3.09	0.96
R-609	0	86.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	15.18	1.77	14.53
U-2011	0	86.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	16.57	3.15	7.04
R-1016&1017	0	87.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	13.46	-0.48	5.14
R-2123	0	87.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	18.42	4.48	18.96
R-523	0	87.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	12.89	-1.04	5.24
R-2000	0	89.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	20.15	5.41	39.12
R-2219	0	90.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	17.75	2.82	8.44
R-2248B	0	90.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	22.44	7.51	18.87
R-2119	0	90.00	0.00	1.00	0.00	3.00	0.00	0.00	1.00	12.68	-2.25	9.06
R-2248A	0	90.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	22.44	7.51	37.66
R-2301	0	91.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	15.27	-0.02	7.44
R-2231	0	91.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	13.64	-1.64	2.65
U-2524	0	91.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	20.86	5.57	49.39
R-0210	0	91.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	18.99	3.70	5.57
R-529 B	0	92.00	0.00	1.00	0.00	3.00	0.00	0.00	1.00	14.54	-1.64	10.75
X-2D	0	92.00	1.00	0.00	1.00	2.00	0.00	1.00	0.00	16.45	0.28	19.42
R-1030	0	92.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	15.61	-0.57	6.91
U-2307	0	92.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	19.65	3.47	9.84
R-2239BC	0	92.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	16.33	0.16	8.62
A-10	0	92.00	0.00	1.00	0.00	3.00	0.00	0.00	1.00	18.48	2.30	4.04
I-2402	0	92.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	22.01	5.84	15.21
R-2247	0	92.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	23.04	6.87	28.27
R-2303	1	94.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	17.55	0.45	4.60
R-2554	1	94.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	16.66	-0.43	8.01
R-2206	1	94.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	20.08	2.99	8.69
R-2552	1	94.00	0.00	1.00	0.00	4.00	1.00	1.00	0.00	24.63	7.54	4.42
U-2579	1	95.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	26.40	9.18	21.12
R-2547/R-2641	1	95.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	27.13	9.90	24.31
R-2633 AB	1	96.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	21.23	3.72	8.30
U-2110	1	96.00	1.00	0.00	1.00	1.00	1.00	0.00	0.00	28.62	11.11	10.52
R-2707	1	98.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	20.63	0.80	9.37
U-2519 AND X-2	1	99.00	1.00	0.00	1.00	2.00	0.00	1.00	0.00	23.25	3.08	16.35
R-2501	1	99.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	20.03	-0.14	12.04
R-2635	1	99.00	0.00	1.00	0.00	1.00	1.00	0.00	0.00	35.76	15.59	26.18

CODE	CNS	BIO	ES	FS	FPM	WPM	RES	BUS	NP	FRM	PC	CI
R-98	39.78	0.10	1.00	1.00	0.00	0.00	1.18	0.50	0.50	0.50	2.00	0.91
U-301	70.65	0.14	4.00	0.00	23.58	1.11	7.02	0.50	0.50	4.00	21.00	0.86
U-203	48.00	0.08	0.00	0.00	12.60	0.00	25.00	0.50	0.50	0.00	7.00	0.82
R-1023	20.14	0.33	2.00	11.00	17.19	22.77	1.92	0.50	0.50	0.00	0.00	0.86
R-1022	20.14	0.07	1.00	0.00	1.66	3.00	1.92	0.50	0.50	0.00	16.00	0.86
U-510,U-608	48.65	0.00	0.00	0.00	23.51	3.97	3.28	0.50	0.50	0.00	103.00	0.91
R-401	21.61	0.09	1.00	1.00	5.33	0.00	0.44	0.50	0.50	0.00	0.00	0.73
U-507	12.09	0.00	0.00	0.00	0.00	0.00	28.50	0.50	0.50	0.00	116.00	0.91
R-606	17.11	0.15	2.00	0.00	6.83	2.66	0.11	0.50	0.50	0.00	14.00	0.59
R-609	61.23	0.06	3.00	0.00	36.88	0.85	13.35	0.50	0.50	0.00	90.00	0.91
U-2011	84.18	0.05	1.00	4.00	16.53	0.52	4.69	0.50	0.50	0.00	94.00	0.59
R-1016&1017	23.56	0.08	1.00	0.00	7.03	0.00	2.39	0.50	0.50	0.00	230.00	**0.86**
R-2123	129.51	0.04	0.00	0.00	32.35	0.97	2.25	0.50	0.50	0.00	535.00	0.77
R-523	36.45	0.08	2.00	0.00	26.55	0.05	2.25	0.50	0.50	0.00	8.00	0.86
R-2000	92.04	0.05	2.00	0.00	26.94	3.64	2.86	0.50	0.50	0.00	125.00	0.86
R-2219	26.93	0.18	3.00	0.00	21.47	0.42	2.20	0.50	0.50	0.00	54.00	0.86
R-2248B	75.50	0.09	1.00	0.00	0.00	1.55	6.03	0.50	0.50	0.00	35.00	0.86
R-2119	59.23	0.13	6.00	0.00	47.23	0.00	2.85	0.50	0.50	0.00	0.00	0.91
R-2248A	92.65	0.12	3.00	0.00	43.06	0.41	9.27	0.50	0.50	0.00	214.00	0.86
R-2301	46.41	0.06	2.00	1.00	23.19	10.73	2.77	0.50	0.50	0.00	7.00	0.86
R-2231	35.88	0.13	7.00	2.00	22.04	1.52	1.79	0.50	0.50	0.00	14.00	1.00
U-2524	81.00	0.06	0.00	0.00	16.62	1.37	22.55	0.50	0.50	0.00	85.00	1.00
R-0210	26.71	0.09	6.00	2.00	15.73	4.60	3.52	0.50	0.50	0.00	1082.00	1.00
R-529 B	39.35	0.11	6.00	0.00	12.90	0.37	4.65	0.50	0.50	0.00	270.00	0.82
X-2D	60.95	0.07	7.00	5.00	25.40	10.01	12.23	0.50	0.50	0.00	0.00	0.95
R-1030	24.35	0.08	3.00	0.00	13.95	2.82	2.18	0.50	0.50	0.00	90.00	0.91
U-2307	33.19	0.08	1.00	0.00	8.87	0.05	6.27	0.50	0.50	0.00	11.00	0.95
R-2239BC	34.64	0.11	1.00	0.00	20.85	1.00	1.67	0.50	0.50	0.00	5.00	0.95
A-10	95.19	0.13	7.00	1.00	106.74	0.26	1.95	0.50	0.50	0.00	333.00	1.00
I-2402	81.93	0.21	3.00	0.00	24.80	1.40	3.01	0.50	0.50	0.00	171.00	1.00
R-2247	80.00	0.13	2.00	3.00	33.14	0.69	16.66	0.50	0.50	0.00	500.00	1.00
R-2303	30.77	0.06	3.00	2.00	12.25	2.12	2.25	0.50	0.50	0.00	47.00	0.95
R-2554	41.00	0.07	2.00	1.00	5.58	1.65	4.86	0.50	0.50	0.00	143.00	0.82
R-2206	41.23	0.00	2.00	1.00	47.67	0.84	3.10	0.50	0.50	0.00	0.00	0.91
R-2552	54.18	0.24	4.00	2.00	28.00	2.22	2.42	0.50	0.50	0.00	0.00	0.95
U-2579	91.89	0.05	2.00	0.00	27.10	0.58	18.80	0.50	0.50	1.50	0.00	1.00
R-2547/R-2641	86.53	0.15	4.00	0.00	33.39	1.71	6.00	0.50	0.50	0.00	21.00	0.95
R-2633 AB	71.75	0.14	14.00	2.00	20.38	15.95	2.58	0.50	0.50	0.00	26.00	0.95
U-2110	60.14	0.38	4.00	6.00	0.71	0.30	0.19	0.50	0.50	0.00	47.00	0.91
R-2707	41.21	0.07	1.00	2.00	10.23	0.01	7.13	0.50	0.50	0.00	1120.00	0.95
U-2519 AND X-2	82.63	0.14	8.00	8.00	28.23	5.99	9.68	0.50	0.50	0.00	319.00	1.00
R-2501	68.51	0.26	4.00	1.00	39.87	3.78	5.88	0.50	0.50	1.00	15.00	1.00
R-2635	68.02	0.19	4.00	0.00	24.54	1.39	6.80	0.50	0.50	0.00	18.00	0.95

APPENDIX G
Data For Trend Analysis

CODE	PRE1993	YEAR	R	U	PID	CP	BR	IPC	IPC1	CRW	CNS	BIO	ES	FS	FPM
R-98	0	1981	1	0	1	0	0	8.673	-0.698	1.2212	6.3072	-0.222	0.1761	0.1761	-0.301
U-301	0	1981	0	1	1	0	0	11.397	2.0256	5.657	8.4053	-0.196	0.6532	-0.301	1.3817
U-203	0	1981	0	1	1	0	0	11.634	2.2626	3.3166	6.9282	-0.234	-0.301	-0.301	1.1173
R-1023	0	1981	1	0	0	1	0	8.308	-1.063	2.0272	4.4874	-0.079	0.3979	1.0607	1.2478
R-1022	0	1981	1	0	0	1	0	8.308	-1.382	1.2821	4.4874	-0.247	0.1761	-0.301	0.3335
U-510,U-608	0	1983	0	1	1	0	0	12.592	10.346	3.4354	6.9748	-0.301	-0.301	-0.301	1.3803
R-401	0	1984	1	0	0	0	1	11.934	0.5667	2.723	4.6484	-0.228	0.1761	0.1761	0.7659
U-507	0	1984	0	1	1	0	0	14.723	3.3556	2.6099	3.4775	-0.301	-0.301	-0.301	-0.301
R-606	0	1986	1	0	0	1	0	10.326	-3.091	0.9807	4.1367	-0.185	0.3979	-0.301	0.8651
R-609	0	1986	1	0	1	0	0	15.185	1.7675	3.8125	7.8249	-0.255	0.5441	-0.301	1.5727
U-2011	0	1986	0	1	1	0	0	16.567	3.1498	2.6537	9.1752	-0.263	0.1761	0.6532	1.2311
R-1016&1017	0	1987	1	0	1	0	0	13.457	-0.478	2.2668	4.8538	-0.234	0.1761	-0.301	0.8767
R-2123	0	1987	1	0	1	0	0	18.416	4.4812	4.354	11.38	-0.271	-0.301	-0.301	1.5165
R-523	0	1987	1	0	1	0	0	12.893	-1.042	2.2897	6.0374	-0.239	0.3979	-0.301	1.4321
R-2000	0	1989	1	0	1	0	0	20.146	5.4051	6.2543	9.5938	-0.263	0.3979	-0.301	1.4383
R-2219	0	1990	1	0	1	0	0	17.752	2.8191	2.905	5.1893	-0.17	0.5441	-0.301	1.3418
R-2248B	0	1990	1	0	1	0	0	22.439	7.5061	4.3444	8.6888	-0.226	0.1761	-0.301	-0.301
R-2119	0	1990	1	0	0	0	1	12.678	-2.255	3.0106	7.6961	-0.198	0.8129	-0.301	1.6788
R-2248A	0	1990	1	0	1	0	0	22.439	7.5061	6.137	9.6254	-0.211	0.5441	-0.301	1.6391
R-2301	0	1991	1	0	0	1	0	15.266	-0.016	2.7268	6.8125	-0.253	0.3979	0.1761	1.3746
R-2231	0	1991	1	0	1	0	0	13.64	-1.641	1.6291	5.99	-0.202	0.8751	0.3979	1.3529
U-2524	0	1991	0	1	1	0	0	20.855	5.5735	7.0278	9	-0.25	-0.301	-0.301	1.2334
R-0210	0	1991	1	0	1	0	0	18.986	3.7044	2.3596	5.1683	-0.228	0.8129	0.3979	1.2103
R-529 B	0	1992	1	0	0	0	1	14.539	-1.637	3.2789	6.2729	-0.218	0.8129	-0.301	1.127
X-2D	0	1992	0	1	0	1	0	16.451	0.2752	4.4072	7.8073	-0.241	0.8751	0.7404	1.4134
R-1030	0	1992	1	0	1	0	0	15.608	-0.568	2.6279	4.9342	-0.234	0.5441	-0.301	1.16
U-2307	0	1992	0	1	1	0	0	19.647	3.4712	3.1373	5.7611	-0.234	0.1761	-0.301	0.9716
R-2239BC	0	1992	1	0	1	0	0	16.333	0.157	2.9352	5.8852	-0.215	0.1761	-0.301	1.3293
A-10	0	1992	1	0	0	0	1	18.476	2.2999	2.0102	9.7565	-0.204	0.8751	0.1761	2.0304
I-2402	0	1992	1	0	1	0	0	22.014	5.8382	3.9004	9.0515	-0.146	0.5441	-0.301	1.4031
R-2247	0	1992	1	0	1	0	0	23.042	6.8662	5.3172	8.9442	-0.204	0.3979	0.5441	1.5269
R-2303	1	1994	1	0	0	1	0	17.546	0.455	2.1443	5.5469	-0.255	0.5441	0.3979	1.1055
R-2554	1	1994	1	0	0	1	0	16.664	-0.427	2.8295	6.4032	-0.247	0.3979	0.1761	0.7837
R-2206	1	1994	1	0	1	0	0	20.079	2.9887	2.9486	6.4208	-0.301	0.3979	0.1761	1.6828
R-2552	1	1994	1	0	1	1	0	24.633	7.5429	2.1015	7.3608	-0.134	0.6532	0.3979	1.4548
U-2579	1	1995	0	1	1	0	0	26.401	9.1789	4.5959	9.586	-0.26	0.3979	-0.301	1.4409
R-2547/R-2641	1	1995	1	0	1	0	0	27.126	9.9039	4.9308	9.3021	-0.187	0.6532	-0.301	1.53
R-2633 AB	1	1996	1	0	0	1	0	21.228	3.7172	2.8806	8.4707	-0.194	1.1614	0.3979	1.3197
U-2110	1	1996	0	1	1	0	0	28.617	11.106	3.244	7.7553	-0.055	0.6532	0.8129	0.0819
R-2707	1	1998	1	0	1	0	0	20.633	0.8042	3.0606	6.4198	-0.247	0.1761	0.3979	1.0305
U-2519 AND X-2	1	1999	0	1	0	1	0	23.249	3.0787	4.043	9.0899	-0.192	0.9294	0.9294	1.4583
R-2501	1	1999	1	0	1	0	0	20.032	-0.139	3.4703	8.2773	-0.117	0.6532	0.1761	1.6061
R-2635	1	1999	1	0	1	0	0	35.759	15.588	5.1163	8.2474	-0.163	0.6532	-0.301	1.3986

CODE	WPM	RES	BUS	NP	FRM	PC	QIX	CI
R-98	-0.301	0.2264	0	0	0	0.3979	0.8667	0.9091
U-301	0.2066	0.8764	0	0	0.6532	1.3324	0.8444	0.8636
U-203	-0.301	1.4065	0	0	-0.301	0.8751	0.8444	0.8182
R-1023	1.3667	0.3834	0	0	-0.301	-0.301	0.8	0.8636
R-1022	0.5441	0.3834	0	0	-0.301	1.2175	0.7778	0.8636
U-510,U-608	0.6503	0.5779	0	0	-0.301	2.0149	0.8667	0.9091
R-401	-0.301	-0.025	0	0	-0.301	-0.301	0.7778	0.7273
U-507	-0.301	1.4624	0	0	-0.301	2.0663	0.8889	0.9091
R-606	0.4999	-0.217	0	0	-0.301	1.1614	0.7111	0.5909
R-609	0.1296	1.1415	0	0	-0.301	1.9566	0.8667	0.9091
U-2011	0.0071	0.7156	0	0	-0.301	1.9754	0.7333	0.5909
R-1016&1017	-0.301	0.4607	0	0	-0.301	2.3627	0.8667	0.8636
R-2123	0.1673	0.4393	0	0	-0.301	2.7288	0.8222	0.7727
R-523	-0.262	0.4395	0	0	-0.301	0.9294	0.8444	0.8636
R-2000	0.6167	0.526	0	0	-0.301	2.0986	0.8667	0.8636
R-2219	-0.035	0.432	0	0	-0.301	1.7364	0.8444	0.8636
R-2248B	0.3118	0.8149	0	0	-0.301	1.5502	0.8667	0.8636
R-2119	-0.301	0.5248	0	0	-0.301	-0.301	0.8667	0.9091
R-2248A	-0.04	0.9901	0	0	-0.301	2.3314	0.8667	0.8636
R-2301	1.0504	0.5145	0	0	-0.301	0.8751	0.8444	0.8636
R-2231	0.3064	0.3599	0	0	-0.301	1.1614	0.9333	1
U-2524	0.2716	1.3627	0	0	-0.301	1.932	0.9556	1
R-0210	0.7075	0.6047	0	0	-0.301	3.0344	0.9333	1
R-529 B	-0.062	0.7121	0	0	-0.301	2.4322	0.8222	0.8182
X-2D	1.0218	1.1047	0	0	-0.301	-0.301	0.8667	0.9545
R-1030	0.5209	0.4284	0	0	-0.301	1.9566	0.8889	0.9091
U-2307	-0.261	0.8304	0	0	-0.301	1.0607	0.9111	0.9545
R-2239BC	0.1763	0.3358	0	0	-0.301	0.7404	0.8889	0.9545
A-10	-0.122	0.3892	0	0	-0.301	2.5231	0.9556	1
I-2402	0.2784	0.5451	0	0	-0.301	2.2343	0.9333	1
R-2247	0.0761	1.2344	0	0	-0.301	2.6994	0.9333	1
R-2303	0.419	0.4387	0	0	-0.301	1.6767	0.9111	0.9545
R-2554	0.3332	0.7288	0	0	-0.301	2.1569	0.8222	0.8182
R-2206	0.1273	0.5561	0	0	-0.301	-0.301	0.8667	0.9091
R-2552	0.4347	0.4655	0	0	-0.301	-0.301	0.8889	0.9545
U-2579	0.0321	1.2856	0	0	0.301	-0.301	0.9556	1
R-2547/R-2641	0.3451	0.8129	0	0	-0.301	1.3324	0.8889	0.9545
R-2633 AB	1.2161	0.488	0	0	-0.301	1.4232	0.9111	0.9545
U-2110	-0.096	-0.162	0	0	-0.301	1.6767	0.8889	0.9091
R-2707	-0.294	0.8827	0	0	-0.301	3.0494	0.9333	0.9545
U-2519 AND X-2	0.8122	1.0079	0	0	-0.301	2.5045	0.9778	1
R-2501	0.6318	0.8048	0	0	0.1761	1.1903	1	1
R-2635	0.2754	0.8634	0	0	-0.301	1.2672	0.9333	0.9545

CLASS	YEAR	PC1	PC2	PRE1993
BEFORE	1981	-1.51253	-0.99552	0
BEFORE	1981	0.63743	-0.18061	0
BEFORE	1981	0.11121	-1.61266	0
BEFORE	1981	-2.02909	1.99894	0
BEFORE	1981	-1.81958	-0.48325	0
BEFORE	1983	0.02436	-1.06671	0
BEFORE	1984	-1.52819	-0.91898	0
BEFORE	1984	-0.39754	-2.30028	0
BEFORE	1986	-2.49411	-0.18331	0
BEFORE	1986	0.71346	-0.46512	0
BEFORE	1986	-0.27889	-0.67929	0
BEFORE	1987	-0.62004	-1.21698	0
BEFORE	1987	0.88036	-1.09317	0
BEFORE	1987	-0.50515	-0.75944	0
BEFORE	1989	1.15803	-0.16855	0
BEFORE	1990	-0.29872	-0.23259	0
BEFORE	1990	0.37513	-0.80406	0
BEFORE	1990	-0.11459	-0.02846	0
BEFORE	1990	1.59585	-0.19924	0
BEFORE	1991	-0.77268	0.74355	0
BEFORE	1991	-0.62694	0.68914	0
BEFORE	1991	1.85605	-0.859	0
BEFORE	1991	-0.09564	0.62906	0
BEFORE	1992	-0.05798	-0.48719	0
BEFORE	1992	-0.01768	1.65204	0
BEFORE	1992	-0.43889	-0.24092	0
BEFORE	1992	0.12441	-0.84733	0
BEFORE	1992	-0.28983	-0.38047	0
BEFORE	1992	0.57841	0.6462	0
BEFORE	1992	0.88871	0.45235	0
BEFORE	1992	1.5466	0.3602	0
AFTER	1994	-0.82148	0.63353	1
AFTER	1994	-0.6502	0.02967	1
AFTER	1994	-0.08082	-0.16105	1
AFTER	1994	-0.50819	1.69489	1
AFTER	1995	1.4638	-0.11593	1
AFTER	1995	1.34589	0.50127	1
AFTER	1996	-0.17779	2.09122	1
AFTER	1996	-0.32643	1.13656	1
AFTER	1998	0.39243	-0.59216	1
AFTER	1999	0.66156	2.00003	1
AFTER	1999	0.55896	1.14383	1
AFTER	1999	1.55033	0.66978	1

APPENDIX H
SAS Codes for analysis

Principal Components Analysis

```
PROC IMPORT OUT= WORK.LUIS2
            DATAFILE= "D:\Thesis_main\EIS-Thesis\PCA.xls"
            DBMS=EXCEL2000 REPLACE;
     RANGE="Sheet1$";
     GETNAMES=YES;
RUN;
PROC PRINCOMP STD out=prin;
      TITLE1 'PRINCIPAL COMPONENTS ANALYSIS';
      VAR PID CP IPC CRW CNS BIO ES FS FPM WPM RES PC CI;
RUN;
PROC gPLOT;
PLOT Prin1*Prin2=CLASS;
RUN;
```

Canonical Correlation Analysis

```
PROC IMPORT OUT= WORK.CANCORR
            DATAFILE= "C:\My
Documents\Thesis\ANALYSIS\EIS_data_DOT\DATA
SET_X5.xls"
            DBMS=EXCEL2000 REPLACE;
     RANGE="CANCORR$";
     GETNAMES=YES;
RUN;
PROC CANCORR all
      vprefix=si vname='Site&Project Information'
      wprefix=ei wname='Environmental Impacts';
      VAR PID CP CRW CNS IPC;
      WITH FPM WPM RES;
      title1 'Relationship between Project Information and Site
Information';
RUN;
PROC CANCORR all
      vprefix=si vname='Site&Project Information'
      wprefix=ea wname='Environmental Assessment';
      VAR PID CP CRW CNS IPC;
      WITH BIO ES FS PC CI;
      title1 'Relationship between SiteProject Information and
Environmental Assessment';
RUN;
PROC CANCORR all
      vprefix=ei vname='Environmental Impacts'
      wprefix=ea wname='Environmental Assessment';
      VAR FPM WPM RES;
      WITH BIO ES FS PC CI;
      title1 'Relationship between Environmental Impacts and
Environmental Assessment';
RUN;
```

Logistic Discrimination

```
PROC IMPORT OUT= WORK.luis
            DATAFILE= "D:\Thesis_main\EIS-Thesis\da_dis_sas.xls"
            DBMS=EXCEL2000 REPLACE;
     RANGE="Sheet1$";
     GETNAMES=YES;
RUN;
PROC LOGISTIC;
   MODEL CLASS = CP IPC CRW CNS BIO ES FS FPM WPM RES PC/
                selection=stepwise slentry=.25 slstay=.25 ctable;
   title1 'Proc Logistic with stepwise selection';
run;
proc logistic nosimple;
  model CLASS = CP IPC ES WPM /risklimits ctable pprob=.72;
  output out= predict predprobs = cross p = phat lower = lcl dfbetas =
_all_
  upper = ucl / alpha =.05;
  title 'logistic regression. class = cp ipc es wpm';
proc discrim crosslist method=npar k=3;
class CLASS;
priors proportional;
var PID CP CRW IPC1 CNS BIO ES FS FPM WPM RES PC;
title 'proc discrim using all variables';
run;
```

Time Trend Analysis

```
PROC IMPORT OUT= WORK.luis1
            DATAFILE= "D:\Thesis_main\EIS-Thesis\trend.xls"
            DBMS=EXCEL2000 REPLACE;
     RANGE="Sheet1$";
     GETNAMES=YES;
RUN;
proc sort;
   by YEAR;
data;
   set;
   yr=YEAR;
PROC MIXED;
   CLASS PRE1993 yr;
   MODEL PC2*= YEAR PRE1993;
   random yr /type=sp(pow)(YEAR);
   RUN;
PROC gPLOT;
PLOT PC2**YEAR;
RUN;


* Replace by CI, WPM, FPM, ES, or PC1 for dependent variable test
```