T-3910

POLITICAL RISK IN THE EXTRACTIVE INDUSTRIES: A TOBIT ANALYSIS OF SELECTED COPPER PROJECTS

by

Janie M. Chermak

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 – 1346

T-3910

A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Mineral Economics).

Golden, Colorado

Date Jan. 31, 1991

Signed: _____
Janie M. Chermak

Approved: _____
Dr. Roderick G. Eggert
Thesis Advisor

Golden, Colorado

Date: Jan. 31, 1991

_____
Dr. John E. Tilton
Professor and Department Head,
Mineral Economics Department

ABSTRACT

Quantification of political risk has received little attention in the extant literature, yet it is a concern to multinational corporations (MNCs) active in the nonrenewable natural resource industries. Recent political changes in many parts of the world warrant a look at the abilities of MNCs to evaluate the potential extent of the effects of political risk. To do this the factors influencing political risk must be identified and a political risk measurement incorporated into economic analyses.

This research departs from existing studies in three ways: 1) hypotheses concerning the determinants of political risk are tested, 2) a quantitative index of political risk is developed based on the variability of the effective tax rate, and 3) this index is incorporated into economic analysis used in a firm's decision process.

Determining the significance of factors influencing political risk cited in past studies and quantifying a measure of political risk is the first goal of this study. A broad definition of political risk, defined as any government action that changes the profitability of a project, is used. The change in the effective tax rate,

used as a proxy for political risk, is incorporated into a limited dependent variable (Tobit) model (as the dependent variable).

The model is applied to investments of MNCs in the copper industry in Chile and Peru from 1960 to 1987. Data from five individual projects, three of which were nationalized, constitute the data set. Five of the nineteen independent variables tested were determined to be significant, including annual percentage change in per capita GDP, the annual rate of inflation, the percentage of GDP contributed by both mining and agriculture, and the percentage of company profits reinvested in the country.

Using the relationships determined from the regression, political risk is determined for a simulated project. This model is linked to a dynamic optimal control model, resulting in a production path maximizing profits of the hypothetical project. The (profit maximizing) MNC, considering investing in this project, chooses both the production path and the time horizon.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

I would like to thank my advisor, Roderick G. Eggert, for the time, patience, interest, enthusiasm, and encouragement which he provided for the duration of this research. I would also like to thank Robert Patrick and Wade Martin for encouragement and insight into many facets of this work, and Laura Pang and Maclyn Clouse for their help, and Lita Dunham for her guidance. I am indebted to Southern Peruvian Copper Corporation for their willingness to provide me with data for their projects. Finally, I would like to thank family and friends for their support and encouragement in completing this work.

Chapter 1

INTRODUCTION

Events of the last three decades have demonstrated how important but difficult it is to assess political risk associated with foreign investments, especially in the extractive industries. An international mining company cannot choose where a deposit is located. Its only choice is to develop or not develop a deposit. When a company chooses to develop deposits in a foreign country, it is tied to that country and that country's government, making it vulnerable to the actions of the host government and often resulting in large losses.

When, in the 1960s and 1970s, governments in the Middle East were nationalizing oil properties, the mineral industry was also plagued by government intervention in South America and Africa. Multinational corporations (MNCs) began reappraising their approaches to foreign investment. The allure of high-grade, low-cost mineral reserves which
initially drew the MNCs to the developing countries became overshadowed by the uncertainty associated with the seemingly erratic behavior of the host governments.

Because of uncertainty it became apparent that a

method of evaluating political risk was necessary. Although many approaches have been tried, most are subjective and the results are impossible to incorporate adequately into economic analyses of investment opportunities. This study, in contrast, models political risk in a manner that can be incorporated in economic analyses. To understand the problems associated with the study of political risk, it is necessary to understand the history of political risk studies.

Political scientists did much of the early work, using case studies of individual foreign operations that had been confiscated. Internal country factors were evaluated as possible determinants of political risk. Many of these factors were qualitative. Both the project specific nature of the studies and the qualitative approach influenced subsequent studies. Even when adequate data became available to evaluate political risk on more than a one-project basis, the emphasis continued to be placed on qualitative factors. Many experts concluded political risk was nonquantifiable because of project specificity and the qualitative nature of the influencing factors.

Another reason for the lack of quantitative work has been the abundance of definitions of political risk. Jodice (1985, 5), offers one of the most complete, defining

political risk as

> changes in the operating conditions of foreign enterprises that arise out of political process, either directly through war, insurrection, or political violence, or through changes in government policies that affect the ownership or behavior of the firm. Political risk can be conceptualized as events, or a series of events, in the national and international environments that can affect the physical assets, personnel, and operations of foreign firms.

Jodice emphasizes political risk is the change in operating conditions brought about by events rather than by the events themselves. This is an important distinction from much of the literature which focuses on the prediction of the events (such as war or insurrection) rather than the change in operating conditions. What is important to a firm considering an investment is the effect government actions have on profitability. It does not matter whether a 50 percent tax increase is imposed because a government is overthrown or because a democratic election installs a new government. What is important is the effect of the 50 percent tax on profitability. Furthermore, prediction of catastrophic events in the political system does not necessarily predict changes in operating conditions.

For this study, political risk is defined as government actions which affect the profitability (either

positively or negatively) of a project. A thorough discussion of risk (its many definitions and why this particular definition is used) is presented in Chapter 2.

This paper, focusing not on prediction of specific events but on the effect events have on profitability, hypothesizes that government actions (affecting profitability of a project) occur as a response to certain factors. Although it is assumed factors precipitating government actions can be quantitative or qualitative in nature, only the readily quantifiable factors are considered (with the exception of dummy variables used to distinguish projects, companies, countries, and election years), resulting in a more objective evaluation of political risk. Economic problems within the country, the perception that an industry is reaping excess profits, social unrest, or election of a new government can precipitate government action.

Bringing conceptualization of political risk together with a quantifiable number is achieved by using the change in the effective tax rate as a proxy for political risk. The logic of this is that profitability is most often affected by government actions which result in a change of the effective tax rate. Tracking the annual changes in the effective tax rate of a project captures the uncertainty,

or the political risk, facing a project.

Purpose and Scope

This study evaluates political risk in quantifiable terms based on the economic, social, and political factors influencing government decisions that affect foreign companies operating within a country and, hence, the political risk faced by these companies. The specific objectives are threefold: (1) to identify potential quantifiable determinants of political risk in the extractive industries, (2) to test the hypothesis that political risk is influenced by these quantifiable factors and that it can be quantitatively analyzed, and (3) given that the second objective is successfully achieved, to incorporate those results in an economic model for evaluating possible mining investments.

The empirical analysis uses a cross-sectional, time-series data set incorporating data from five copper projects (El Salvador, El Teniente, Chuquicamata, Touquepala, and Cuajone), owned by three different firms (Anaconda, Kennecott, and Southern Peru Copper Corporation) in two different countries (Chile and Peru). Two of the Chilean projects were nationalized in 1969 and the other in 1971. The Peruvian projects are still privately owned.

The period studied is from 1960 to 1987, although not all the projects were in operation over the entire period. Only the years in which the projects are privately operated are included.

Methodology

Important factors influencing political risk are identified by reviewing the existing literature. Readily quantifiable economic, social, and political factors presented by various authors are considered in this study. These factors are considered in the framework of how they influence government decisions that result in increased or decreased political risk. When two or more factors are encountered capturing the same effect, the factor with the more reliable data source is used.

Testing the hypothesis that political risk is influenced by quantifiable factors and that a measure of political risk can itself be quantified is achieved through econometric modeling. The determinants of political risk, identified in the first part of the study, are incorporated into a Tobit model. The Tobit model is used because the dependent variable (annual change in effective tax rate) cannot take on any value between negative and positive infinity (as is the case with ordinary least squares) but

rather is restricted to values from negative to positive one. This is a censored regression, with both lower and upper limits truncated, using the maximum likelihood method for the regression analysis.

The economic model incorporates the regression results into a dynamic optimal control model which defines the best depletion path of a mine, owned by a profit-maximizing firm in a perfectly competitive market. This hypothetical example, set in the short-run, imposes only a stock constraint. Using the optimal depletion path, the net present value of the project is determined. The purpose is not to determine the profitability of a real project but rather to demonstrate how the political risk model can be incorporated into economic analysis.

Overview

Chapter 2 reviews and discusses the political risk literature. Chapter 3 focuses on the political risk definition, its proxy, and the determinants of political risk. Country-specific and industry-specific factors are discussed. A brief history of each country in the study and data sources are also included in this chapter.

Chapter 4 outlines the methodology of dependent variable models, discusses why a Tobit model is used and

the shortcomings associated with this model type. The results of the empirical analysis complete the chapter.

Chapter 5 incorporates the political risk model from Chapter 4 into an economic analysis for a hypothetical project. The methods of discounting, when risk is involved, are discussed. The change in the effective tax rate for the example are forecast. These results, incorporated into an optimal control model, determine the optimal extraction path (based on profit maximization); resulting in a political risk adjusted, net present value of the project.

Chapter 6 discusses the conclusions, limitations, and contributions of this research, as well as areas for future research.

Chapter 2

LITERATURE REVIEW

In the diverse body of literature dealing with political risk there is no universally accepted definition and no most favored type of analysis. Kobrin (1979, 75) reviewed the existing literature on political risk and made the following comments

> It is clear that managers consider political instability or political risk, typically quite loosely defined, to be an important factor in the foreign investment decision. It is just as clear that rigorous and systematic assessment and evaluation of the political environment is exceptional. Most political analysis is superficial and subjective, not integrated formally into the decision making process.

Kobrin's quote is as timely today as it was a decade ago.

Political risk literature generally falls into two categories. The first category follows the historical evolution of political risk research and is divided into three groups. The second category covers the assessment methodologies of political risk.

Historical Evolution of Political Risk Studies

Prior to the late 1950s political risk was viewed as a diplomatic problem. The focus was on enforcing

international law in political risk incidents. Most attention focused on compensation for confiscation rather than disputing the rights of countries to nationalize private property. The literature through much of the 1950s focused on the legalities of political risk rather than on its causes. The literature review in this chapter focuses on the literature which deals with the causes of political risk, rather than with the diplomatic concerns.

The three literature groups of the evolution of political risk are discussed below. The first group deals with the models of political risk, the second with individual case studies which were carried out as data became available, and the third deals with factors of political risk (the result of more data).

Political Risk Models. As stated above, the first literature group concerning the evolution of political risk literature deals with political risk models. The first three of these models, developed in the mid to late 1950s, the 1960s, and the early 1970s, explore the impetus for governmental confiscation of private property. They are not empirically proven and are quite different in their approaches. These models have influenced much of the work in political risk. The fourth model (from the 1980s) suggests how to minimize political risk in future projects.

The importance of presenting this model is that some of the factors it addresses as necessary for reduced political risk are factors which have been considered by other researchers as influencing political risk. As is the case with the first three models, there is no empirical work associated with the model.

Bronfenbrenner (1953, 1954) suggests expropriation can be explained in terms of the concrete economic benefits derived by the host country. He presents the argument that confiscation can be a viable alternative for the host country elites as a way to increase the rate, or to modify the course, of economic development. His hypothesis deals with confiscation of all private assets; the Soviet Union and China are cited as examples where confiscation has been an effective tool for economic development. Bronfenbrenner argues that confiscation rather than "killing the goose which laid the golden egg" (p. 201) has greatly enhanced the development in certain countries.

Johnson (1965), who proposed another model for economic nationalism (an early term for political risk), hypothesizes that its sources are nonrational, extra-economic, ideological, or purely emotional. This "psychic satisfaction" (p. 177) approach to expropriation has received much attention in the literature. Johnson argues

that the governing elites of a developing country and the population at large are often willing to sacrifice material advantage for the psychic satisfaction of nationalistic acts. Prime among these are actions such as expropriation of foreign controlled companies and displacement of foreigners by nationals in high prestige jobs.

Although Johnson's model presents a plausible explanation for expropriation, it is largely based on speculation. There is, most likely, validity in the purely political aspects of governmental actions, but this model ignores quantitative factors which contribute to economic nationalism or political risk.

Vernon (1971) proposed the "obsolescing bargain" to explain the dynamics between MNCs (in the extractive industries) and host governments. He looks at the change in power occurring during the life of a mining project. At the beginning of an extractive project the MNC holds the power because the host government, owing to a lack of capital and expertise, is unable to develop a project and is willing to make concessions to the MNC. After the project is profitable, the host government may realize it gave up large future revenues. Because the mine cannot be physically moved, the host government can use it (ownership) as a bargaining position to renegotiate

contracts. The MNC has little recourse except to negotiate because it may risk losing the project altogether.

Several authors have suggested actions which will reduce political risk. Mikesell (1981) and Daniel (1989) address the factors which need to be present in order to minimize or eliminate political risk. Basically, these models involve the negotiation of the most fair contract between host government and MNC at the inception of a project. This involves the MNC receiving a maximum pre-specified rate of return (ROR). The government receives revenues in the form of an income tax, a royalty tax, and after the prespecified ROR of the MNC is reached, the remaining profits are taxed away in the form of a Ricardian rent tax. It is suggested that with such a system the government will be extracting the highest amount of revenue possible from a project and will not try to increase that amount in the future.

Several conditions are considered imperative for this system to work. First, competition between MNCs for the right to explore and produce in the developing country is deemed necessary. Second, the ROR has to be acceptable to both the MNC and the host government. And third, future governments must be willing to accept the prior agreement. It is difficult to always assure competition among MNCs

for the right to explore and develop. It may be even more difficult to arrive at an ROR which will satisfy both the MNC, the current government, and any future government. Although the basis for this minimized political risk model is sound, it is naive to think it will alleviate political risk.

The models presented here are diverse. This diversity emphasizes the lack of continuity in political risk literature. The models' influence can be seen in the approaches used to evaluate the general causes of political risk.

Case Studies. The second literature group in the historical evolution of literature, developed in the 1960s and 1970s, deals with case studies of events. Occurrences which reduced the profitability of a specific project or forcefully dictated an ownership change (in the various forms of property confiscation) increased at a rapid rate during the 1960s and 1970s. Both manufacturing and mining ventures were targeted. As the problem became more prevalent, research in the area increased. Political scientists were among the first political risk researchers, and they placed emphasis on "political instability" in the form of revolutions. This resulted in qualitative studies which, as noted by Robock (1971, 8), did not "produce the

answers needed for international business."

Lack of data impaired empirical political risk work in the 1960s and early 1970s, resulting in few economic studies. This reinforced the general perception that quantitative studies are not possible. The reasons most often cited are the specificity of political risk and the influence of nonquantifiable factors. These may be due more to the evolution of the study of political risk than to actual fact.

Many early studies were case studies concentrating on one specific country and one specific commodity. In the early 1970s many of these case studies concentrated on expropriation of mineral projects. Notable among these were studies by Moran (1974) and Ingram (1974).

Moran studied the Chilean copper industry and the development of governmental policies which ultimately ended in the nationalization of the industry in 1972. Ingram also used a case study approach in analyzing the nationalizations which occurred in Chile, Bolivia, and Peru. During the early 1970s a case study was about the only approach possible because of the lack of data bases. This early work is excellent, but it may have set the tone of future research in that many researchers may have had the preconceived notion that political risk was project

specific and the possibility of common, readily quantifiable factors was dismissed.

Political Risk Development. The third literature group in the evolution of political risk developed as more data became available. Research took many paths with increased data availability. Many students of political risk focused on a subset rather than on the entire subject. One of the most popular areas of study was the prediction of government overthrow. These predictions were based on such factors as number of acts of civil disobedience, riots, or strikes. This area of political risk is not of major importance in this study because it has not been proved that an overthrow of the government in power always results in increased political risk or in expropriation of private property. As more data became available, the scope of the studies broadened. Kobrin (1980) focused on the firm and the firm-specific factors conducive to expropriation. Jodice (1980) studied expropriation given characteristics of the host country, foreign investment, and the host country's dependence on the international system. Both of these studies are cross-national and dealt with manufacturing as well as mining firms. These studies gave insight into political risk and the interactions of host governments and MNCs but fell short of quantifying

political risk in a usable form.

Other work in the political risk literature focuses on peripheral aspects of political risk (as defined in this study). Root and Ahmed (1979) were some of the first to try empirical analysis. Rather than study political risk, they studied the determinants of direct foreign investment in the manufacturing sector. Even though they analyzed relative attractiveness of investment, insight can be gained from their determining factors. They approached this study by compiling all variables discussed in previous works. Of the thirty-one original variables, six were significant in the level of direct foreign investment. Even though political risk is not addressed as such, several of the six factors can be associated with political risk. These include transfer of government (tenure in office), per capita GNP, and the GNP growth rate.

The major portion of academic research has dealt with factors, models for investment, and prediction of major political conflict, but has not adequately dealt with political risk in an investment context. The work done in the quantification of political risk has mainly been that of consulting firms for companies, by individual MNCs, and, most recently, by banking institutions.

Assessment Methodologies

The second category of literature focuses on the assessment of political risk used by MNCs today and the possible future trends of risk assessment.

Most students of political risk agree that political risk is affected by sociocultural, political, and economic phenomena. Analysts incorporate these factors into a framework assessing political risk in many different ways. Many classification systems of political risk indexes have been developed, but perhaps one of the most straightforward classifications divides the approaches into three categories: expert-generated opinion, component, and empirical-formal observation.

Expert-Generated Opinion. The expert-generated opinion is one of the oldest employed by MNCs and include "grand tours," "old hands," and Delphi technique approaches. The "grand tour" is simply a visit to the country in question by the top management of the company. From that visit, investment decisions are made. This is at best subjective decision making and at worst subjective, uninformed decision making. The old hands approach incorporates the opinions of people with experience in the country. The decisions made from an old hands approach can be based on subjective, biased evaluations. Grand tours

and old hands analyses are not often used anymore and have been replaced by methods which are thought to be less biased.

The Delphi approaches used are in many ways an improved version of the old hands approach. Opinions are solicited through a structured interview system from several people who are considered knowledgeable. From these opinions a decision is reached. Because many opinions are solicited, bias is supposedly lessened.

There are many examples of expert-generated opinion models generated by various organizations. Lax (1983) discusses several of these. Three of the best known and most used are the Business Environmental Risk Index (BERI), the Business International (BI) system, and Nikkei's Business Index (NBI).

BERI (also known as the Operations Risk Index) uses fifteen variables that are thought to be related to political risk (Haner, 1981). Each variable is weighted. The score of the variables is summed, with 100 being the highest possible score and corresponding to the lowest possible political risk.

The BERI ratings are obtained by using a Delphi interviewing technique with a permanent panel of experts. There are more than a hundred experts used who reside in

the United States and in the country in question. Each expert subjectivity assigns a score to each variable. After the initial responses the experts are informed of the mean response for the country and they can adjust their scores if they want. The final score for the country is made by throwing out the high and low scores and taking the average of the remaining scores. Approximately forty-five countries are covered each year with this system.

BI uses a technique similar to BERI but with different variables and different scoring techniques. The predictions from BERI and BI have been remarkably similar (Haendel, 1979). The NBI system has been called the Japanese version of BERI and BI (Kennedy, 1985). The system ranks the investment appeal of over 50 countries for Japanese firms.

Component Approach. The component approach attempts to measure and relate variables which influence political risk. This approach chooses structural causes of political risk and tries to objectively measure the factors. These models still have a degree of subjectivity.

One of the oldest component models is the Political System Stability Index (PSSI). Three equally weighted indices (socioeconomic, societal conflict, and internal violence subindex) are used to generate an overall score

which can be either positive or negative (Haendel, 1979). The more negative the number, the greater the political risk. All of PSSI's operational variables are measured quantitatively, which leads to an aggregate score for the country. Even though these are quantitative measures, they are guided by many subjective considerations. The most blatant is that the variables and their interrelationships are not supported by empirical theory, and the three indices are given equal weight (also not supported by theory). Another component model, developed by Green (1974), focuses on the interrelationship between political structure and political stability. This model suffers from biases similar to those in the PSSI model. The assumptions regarding political stability and various political systems are questionable. Liberal democratic regimes are considered the most stable, followed by modernizing autocracies, military dictatorships, mass mobilization regimes, and newly independent states. This ranking of relative stability was not tested empirically but was simply assumed.

Formal-Empirical Observational Models. The formal-empirical observational models attempt to measure the structural causes of political risk. Unlike expert-generated opinion or component models they avoid subjective

analysis. Only data that is considered "hard observational" data that has been empirically tested are used. Quantitative scores are generated and are compared across countries. One such model, developed by Knudsen (1974), is derived from the J-curve theory of revolutions and is based on the frustration level of a society as the major factor affecting stability. For instance, when welfare levels drop quickly and aspiration levels remain unchanged, a frustration gap develops and the probability of revolution increases. Another empirical-formal model was developed by Douglas Hibbs (1973). Hibbs developed a causal model of mass political violence by using factor and regression analysis.

The main objections to the "formal-empirical" observational models presented above are two-fold. First, it can be argued that the data used is not necessarily hard observational data. How exactly does one measure in hard terms the aspiration levels of a population? Second, and perhaps more important, is the fact that these models measure the probability of revolution or mass political violence; but acts such as these do not necessarily lead to increased political risk. This again points out the problem of the multitude of definitions for political risk.

How well do the expert-generated, component, and

empirical-formal models work? There have been no long term studies to find out how these systems work over time. However, all of the models presented above were in existence before the 1978 Iranian revolution. The only one which categorized Iran as having a high potential for political instability was the Hibbs' model (Kennedy, 1985). The rest of the methods categorized Iran anywhere from "one of the most stable Mid-Eastern countries" (Green, 1974) to "moderately risky" (BERI). Although this is just one example of the success (or lack thereof) of these approaches, it does point out the need for more accurate methodologies.

Many companies choose to generate their own risk assessment profiles of countries. General Motors is one. Its International Economics Group (IEG) is directly responsible for country risk assessments. The technique used by IEG is primarily qualitative and oriented toward policy issues. The economic and political analyses focus on government actions which will influence the operating environment for GM. From this they determine whether a specific GM activity will be profitable and whether that profit can be expatriated to the United States. The GM approach can best be described as a component approach to risk assessment.

Many banks today have their own risk assessment procedures. They are interested in the "creditworthiness" of a country. Creditworthiness is really just another name for political risk when it pertains to banking institutions. Bankers Trust has its own form of political risk assessment. Its approach is based on an economic and political analysis. Typically a risk assessment profile of a country is made by the country economist and by the risk analyst (individually). From these assessments and from the raw data available, a decision is made by a panel. Bankers Trust emphasizes that its risk assessment technique is largely qualitative because many factors it finds important cannot be quantified.

The company assessments have the same problem as the other models presented in that it has not been established how successful or unsuccessful they have been.

The academic approaches presented in the evolution of political risk studies section discuss factors influencing political risk. The country risk assessment techniques presented create indices and other approaches to political risk. None of these are of much use in economic analysis.

Though many political risk experts are quick to point out the reasons for not to using an econometric approach, the apparent lack of success of the mainstream methods

emphasizes the need for new evaluation techniques. Perhaps the most innovative, new technique which has been formulated is an econometric model that has been used in banking. A qualitative choice model (Logit) using a binary dependent variable for rescheduling of loan payments (0 = no rescheduling, 1 = rescheduling) is employed, using data to estimate the probability of each of these occurrences for a particular country. Different studies have used different independent variables, but all use economic data that are readily measured.

The political risk literature is diverse. Most falls short of being effective in analyzing political risk from an investment viewpoint. The econometric work from the banking industry is one of the newest methods and one of the only methods which relies solely on readily quantifiable data. The majority of the analyses are heavily weighted toward qualitative or subjective quantitative data which cannot be incorporated into economic evaluations of investment options.

Chapter 3

MEASURING POLITICAL RISK, ITS DETERMINANTS, COUNTRY CHOICES, AND DATA

This study hypothesizes that political risk is not project, company, or even country specific, but rather that determinants of political risk transcend country borders. Furthermore, many variables affecting political risk can be objectively quantified, and consequently political risk can be econometrically modeled. In order to accomplish this it is necessary to define political risk and to determine exactly what is being measured.

Risk, Political Risk, and Its Measurement

Webster's New Collegiate Dictionary (1981, 992) defines risk as follows

> 1: possibility of loss or injury: PERIL 2: a dangerous element or factor 3 a: the chance of loss or the perils to the subject matter of an insurance contract; also: the degree of probability of such loss b: a person or thing that is a specified hazard to an insurer <a poor ≈ for insurance> c: an insurance hazard from a specified cause or source <war≈>

This multipart definition brings out the many meanings of risk. The statistical definition employed deals with a mean value and the variance around that value. The

epidemiological definition focuses on "relative risk." That is the odds ratio, such as the odds of having cancer being 5 in 100. Risk is often defined by the probability associated with a specific outcome.

The term "political risk" takes on different meanings in different studies and, as was suggested earlier, there is no universally accepted definition. Discussing all political risk definitions could be a paper in itself. Lax (1988) summarizes a portion of the definitions (Table 3.1). The comments in parentheses after the definition are Lax's categorization of the definition. The Lax summary is by no means exhaustive but it adequately points out the diversity in definitions.

This study defines political risk as government action(s) resulting in a change in profits from a given investment. This definition, as with many political risk definitions, does not contain a probability element. This broad definition encompasses everything from actions such as government overthrows, to elections and the peaceful transfer of power, to expropriation or nationalization of private property or industries, to changes in the tax laws. The specific action is not what is important, but rather how that action affects profitability. Only when actions affect profitability can they be considered political risk.

Table 3.1 Political Risk Definitions

Author/(Year)	Definition
Stobaugh (1969) (instability)	General conditions affecting investment conditions
Business that International	Ambiguous; concern with things affect businesses (instability)
Robock (1971)	Difficult to anticipate discontinuities in business environment caused by political change and which might affect profits or other goals of the firm (instability)
Boddewyn & Cracco (1972)	Whether government will adopt more or less nationalistic policies (policy)
Green (1974)	Adverse changes stemming from radical political changes (instability)
Rummel & Heenan (1978)	Ambiguous; concern with political changes (instability)
Johnson (1980)	Politics and economics are inseparable in causing business, financial, and catastrophic risks and events (instability and policy)
Haendel, West & Meadow (1975)	Risk of occurrence of political events that change prospects of profitability of a given investment (instability)
Truitt (1974)	Propensity to expropriate (policy)

(continued)

Table 3.1 (continued)

Author/Year	Definition
Jodice (1980)	Propensity to nationalize and expropriate (policy)
Bunn & Mustafaoglu (1978)	Political risk event as any outcome in host country that would have a negative impact on the success of a venture (policy and instability)
Shell Oil (1978)	Probability of not maintaining oil contract during a period of 10 years in the face of changing economic and political circumstances (policy)
Brewer (1984)	Listing of specific risks that tend to emerge from political processes (policy)
Frost & Sullivan (1982)	Probability of various types of restrictions or losses (policy)
Channon & Jallard (1978)	Political intervention (policy)
Kobrin (1980)	Forced divestment (policy)
Lax (1983)	Likelihood that political changes will prompt a change in the investment climate regulating a project or contractual agreement (policy)

Source: Lax, H. L., 1988. State and Companies: Political Risks in the International Oil Industry. New York: Praeger.

How can a government action be measured? Incorporating a magnitude of the action, or more accurately, the risk or effect on profitability, necessitates the use of a scale for the dependent variable. Government actions often manifest themselves in changes in the tax regime. Therefore the annual change in the effective tax rate (CETR) assessed against a project is used here as a proxy for political risk. The effective tax rate includes income tax, effects of (fixed) exchange rate transactions, export taxes on the product, import taxes on equipment, mandatory labor shares transferred to workers (based on profits), plus any extraordinary taxes assessed against a project. Taxes paid to the U.S. government for profits on the project are not included. When losses occur for any year and those losses are used in future years to reduce future tax burdens, the effective rate in the future year reflects the reduction from the previous loss. Table 3.2 is an example of the effective tax rate calculation using information from the annual reports for the Southern Peruvian Copper Company. Using the effective tax rate, CETR can easily be calculated.

No "subsidization effects" of other policies (such as mandatory social programs financed by the MNC) are considered in the effective tax rate. In the case of

expropriation or nationalization the effective tax rate is 100 percent,

Table 3.2 Example of Effective Tax Rate Calculation
Toquepala Mine, 1979 Effective Tax Rate

Gross Profits	$134,200,000	
Taxes	$106,500,000	
Income Tax		
Peru - Current		$56,500,000
Peru - Deferred		(-1,600,000)
Export Tax		49,700,000
Worker Participation		1,900,000
Net Profit	$ 27,700,000	

Effective Tax Rate = Total Taxes/Gross Profits
= $106,500,000/$134,200,000
= .7935

Source: Southern Peruvian Copper Corporation Annual Report 1979.

meaning the MNC (previous) owner has had all profits taken by the government. This not only allows for the incorporation of the more common (less dramatic) tax changes but also for the less common (more dramatic) actions of expropriation. Using the CETR allows for both positive and negative effects of political risk and, consequently, increases as well as decreases in expected profits.

It should be emphasized that the change in effective

tax rate is used rather than the effective tax rate. This is because risk is associated with the variation in tax rate from year to year rather than with some specific tax level. A country can impose a 90 percent tax rate and, although this is extremely high, it cannot be considered risky if it is a constant rate. Figures 3.1 through 3.5 graph the changes in the effective tax rates for the projects considered in this study. As can be seen there are very few years in which there was no change.

A possible concern of using an effective tax rate proxy for political risk is that the effective tax rate

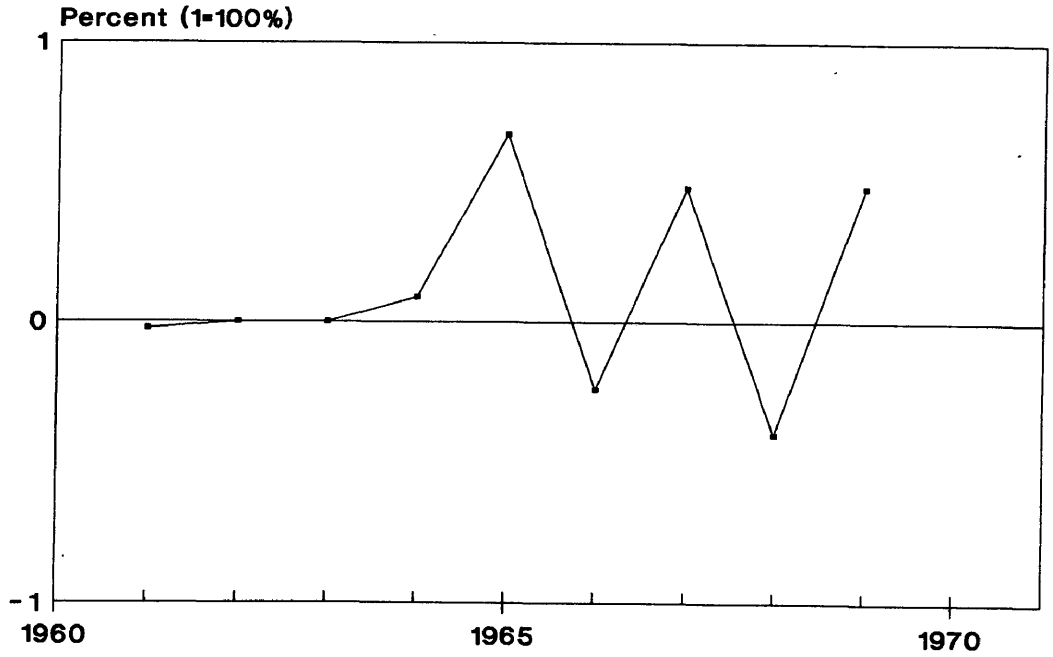

Figure 3.1 Annual Effective Tax Rate Changes
El Salvador Mine, Chile

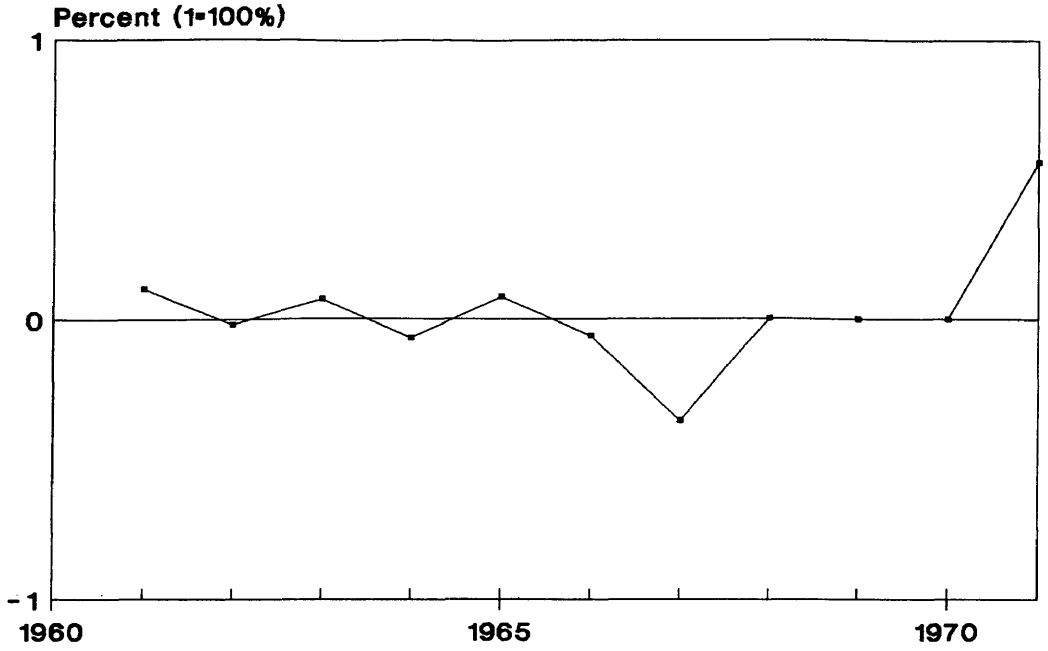

Figure 3.2 Annual Effective Tax Rate Changes
El Teneinte Mine, Chile

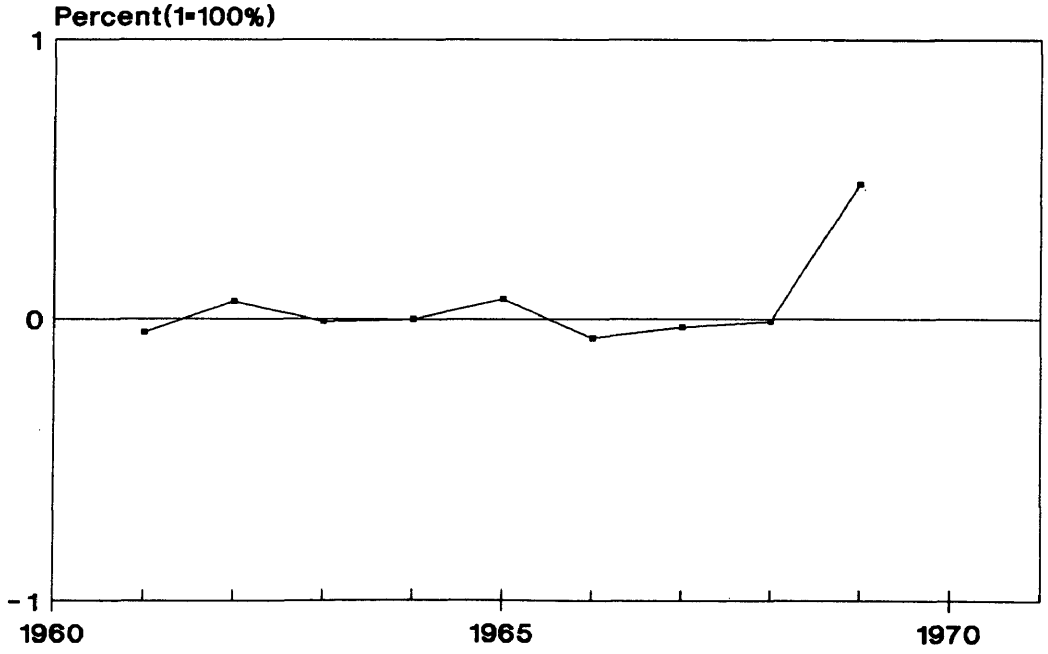

Figure 3.3 Annual Effective Tax Rate Changes
Chuquicamata Mine, Chile

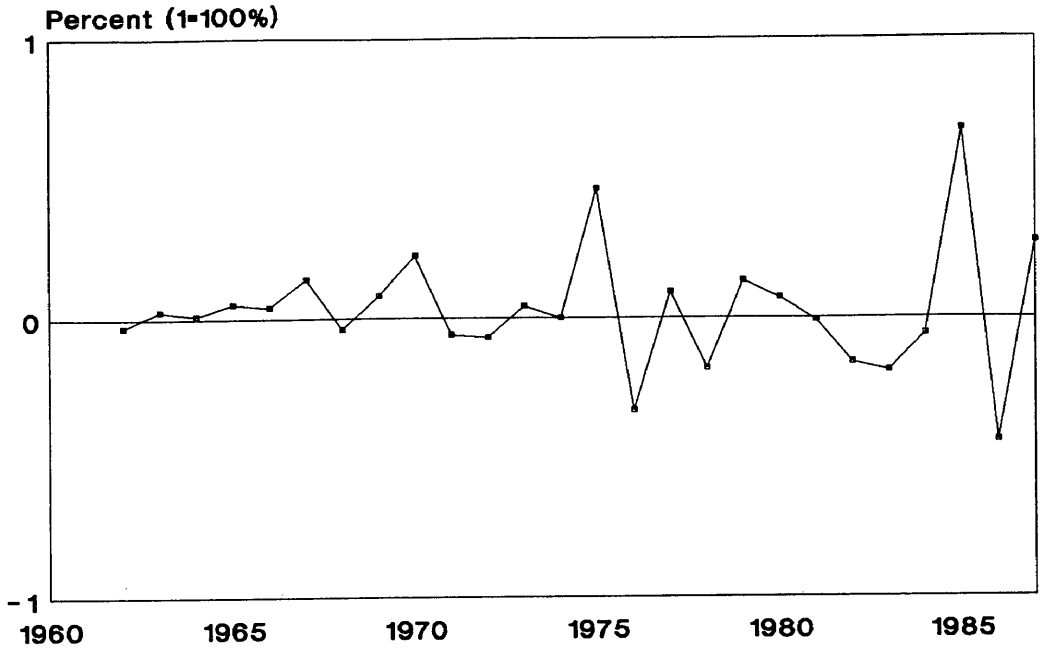

Figure 3.4 Annual Effective Tax Rate Changes Toquepala Mine, Peru

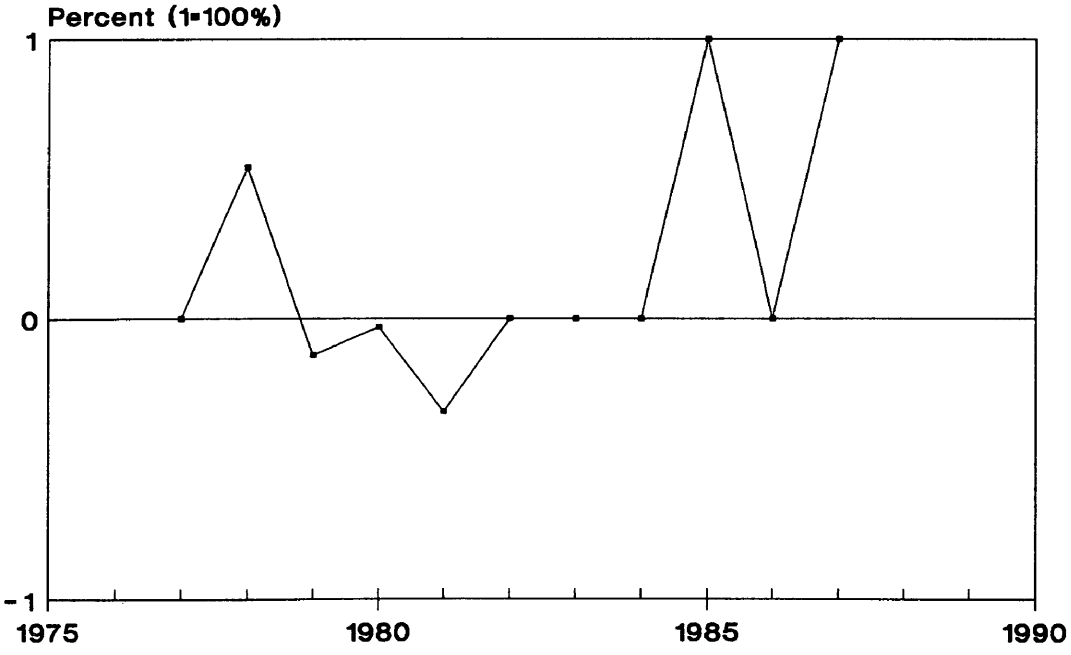

Figure 3.5 Annual Effective Tax Rate Changes Cuajone Mine, Peru

depends somewhat on the actions of the MNC. Its tax burden can (in some instances) be reduced by choosing a certain output level, or by the amount of money repatriated to its home country, or by the percentage ownership carried in a project. For this reason it could be argued that an effective tax rate should be considered an endogenous variable and is not a true proxy. However, by the definition used, true political risk can only be considered as that portion of government action or intervention which cannot be dissipated by company reaction.

The premise of this study is that a government will choose those actions which result in its continued success and tenure. This can be considered rational choice by the government. Government's perception of situations and events will precipitate actions or reactions. Those situations and events which encourage government intervention are (or at least influence) the determinants of political risk. These determinants, or independent variables, are discussed in detail in the following section.

Determinants of Political Risk

Stability within a country is important to the government. Economic stability, meaning stable economic

growth, can lead to citizen contentedness and public approval of the government. This in turn leads to stability in the government's ability to retain power. Although these are closely intertwined, there are factors which affect the government's ability to sustain economic growth and other factors which are more closely tied to the satisfaction of the population in being able to maintain a certain standard of living. Declining stability in either of these areas can result in government action to enhance the economic situation or simply to appease the electorate.

The variables chosen address situations that could result in the government losing its ability to govern effectively or to lose its popularity with the population. Previous works have defined a multitude of determinants considered important to political risk; the majority of variables in this study were taken from past works. Table 3.3 lists variables from previous works considered in the study, the anticipated sign of the coefficient for the variable, and authors who have presented the specific variable.

In some instances the variables listed in Table 3.3 were not used in the study owing either to circumstances within the countries included in the study or to a lack of adequate data. When such a problem occurred a substitute

Table 3.3 Determinants from the Extant Literature

Variable	Effect	Source
Country Specific		
Economic		
Annual Percentage Change Per Capita GDP	-	Root/Ahmed (1979)
Foreign Exchange Rate	-	Daniel (1989)
Manufacturing/GDP	-	Stobaugh (1969)
Foreign Trade Balance	-	Brainard (1981)
Export Composition	+	Raddock (1986)
Political		
Tenure of Government	+	Root/Ahmed (1979)
Campaign Year	+	Kobrin (1979)
Social		
Level of Education	+	Nagy (1981)
Income Quintiles	+	Hershbarger/Noerager (1976)
Industry,Company or Project Specific		
Price Differential	+	Moran (1974)
Reinvestment from project	-	Ray (1976)
Government Revenues MNC Profits Ratio	-	Becker (1983)
Age of Project	+	Vernon (1971)
Percent Foreign Ownership of Project	+	Ingram (1974)

variable was used or a dummy variable was included. These cases are covered in the discussion of the variables. The variables are categorized by the situation they are assumedto capture. Many variables in different studies capture the same effect. When this occurs the variable which appears most representative or most easily quantified is used.

Nonquantifiable variables are excluded from this study. This reflects the ambition of the study to be unbiased and does not imply that nonquantifiable variables do not affect political risk. The variables chosen can be divided into country specific and industry specific. Within each of these divisions there are several subdivisions.

Country Determinants. The first group of variables discussed are country specific factors. Within this group are economic, political, and social factors. Economic factors can be diverse, but in general they capture the economic stability of the country, the welfare of the citizens, or the strength of the country in the world economy. It should be noted in this discussion that a positive relationship between an independent variable and the effective tax rate expects the two to move in the same direction (both increasing or decreasing).

The rate of economic growth in a country is vital in the economic stability of a country. The percentage change in per capita GDP (in constant local currency) is used to represent the rate of economic growth. A constant positive growth rate would indicate contentedness of the population because of improving welfare. Negative growth, indicating declining welfare in the country, would result in discontent and possibly government actions which would reduce the profits from a project. It should be noted that in some instances of extremely large annual growth rates, stability of a country can be lessened as was the case in Iran in the late 1970s. This, however, is not the case in the countries included in this study. A positive per capita GDP growth rate is expected to decrease the effective tax rate.

The rate of economic growth in a country should not be confused with the level of economic development in a country. The level of economic development refers to where in the development process a particular country stands. GDP growth is a common measure but is misleading because GDP growth does not give an indication of how much can be purchased; goods cost different amounts in different countries. GDP, then, is not a good indicator across countries for level of development.

The annual percentage change in real per capita GDP indicates the steadiness of growth but does not measure inflation, also a concern. Foreign exchange rate is often cited as a good indicator of inflation in countries that import many goods. The countries in this study both had fixed exchange rates for several years which would result in an inaccurate representation of inflation and is therefore not included.

Economic diversity in a developing country is an indicator of economic stability. An economy which is strong in several sectors is not at the mercy of one specific industry; consequently, simultaneous development of several sectors allows for more stability than a one-sector economy. Therefore, manufacturing as a percentage of GDP is included in the study as it is often used as an indicator of development diversity. Again, a caveat is in order. It can be argued that at a certain point, the manufacturing/GDP ratio would indicate an economy which is dependent on manufacturing. Currently, however, there is not a country in which manufacturing is the majority sector of GDP (defined as either the largest sector or > 50 percent of GDP). The anticipated coefficient for the manufacturing/GDP variable is negative. Having a manufacturing sector should lessen the burden on the

extractive sector. The magnitude of the effect depends on the size of the manufacturing sector. The annual change in the trade balance is also considered. Fluctuations between being a net exporter and a net importer would indicate possible instability in an economy. A positive trade balance is expected to decrease the effective tax rate.

In addition to the importance of the trade balance is the composition of the country's exports. As Raddock (1986, 45) points out, "Dependence on one commodity for 30 to 50 percent of the economy's foreign exchange would be cautionary, while more than 50 percent is considered alarming." In this study the percentage of total exports contributed by copper is included. Fluctuations in the trade balance (net exporter to net importer) that are (or are perceived as being) caused by a specific industry may result in governmental discontent toward that industry. A positive correlation between the percentage of exports contributed by copper and the effective tax rate is expected.

The next group of factors considered is political factors: (1) the tenure of the government in power and (2) presidential campaign years. The longer the tenure of a government the more likelihood there is for a higher disapproval rating from the people (which does not imply

the converse). In trying to gain approval, a government is likely to make policies which are visible and which tend to hurt (or at least appear to hurt) a nonvoting entity. A highly visible, foreign-owned, high-profit company is a viable target. A positive correlation between years in power and the effective tax rate is expected.

Kobrin (1979) hypothesizes that a government is more likely to take actions against a project or industry during a presidential campaign year in order to gain voter approval. It could be argued that in many countries, such as Chile, any election is sending signals to the highest elected political offices and therefore most years could be considered "campaign years" (in the pre-Allende period). However, it may be that national level government may have more impetus to act in those years when their offices are up for election. Therefore a presidential election campaign year dummy variable is included which actually may capture two factors. First, it captures those years in which a government in power retains power. Second, it distinguishes between peaceful transitions in governments and coups (when taken in combination with the tenure in office variable). A positive relationship between the campaign dummy variable and the effective tax rate is expected.

A second dummy for government type (democracy or military dictatorship) could also be included. This, however, may be a subjective variable because of the drastic differences in military governments and their idealogies. Categorizing these would be from a democratic bent and, most likely, biased.

The third group of country factors are social factors, which are also considered important in the stability of a developing country. Social factors are the hardest to incorporate owing to their qualitative and subjective nature. Level of education and literacy are two factors which are often cited as influences of political risk. Because of the qualitative nature of these determinants they are not included in the study. This does not imply a lack of importance of these factors, simply a desire to keep the study as unbiased as possible.

Income quintiles are discussed in the existing literature as influencing political risk. The argument cited until recently was that an income distribution which concentrates a large percentage of income in a small percentage of the population would, in and of itself, indicate discontent and possible instability. This has largely been disproved in historical and sociological studies of revolution and revolt. The other argument which

is still considered valid is that in a developing country, an increase in the middle class quintiles results in instability because the newly formed middle class no longer fits in with the lower class from which they came but are also not completely accepted by the upper classes. For the countries studied, income quintile data was not kept for the relevant time period and so is not included in the study.

It is not the intent of this study to minimize the importance of social factors. Lack of available data for social factors does not allow them to be included. Instead, a country dummy variable will be included to capture social factor effects.

Industry Determinants. Whereas the country-specific factors emphasize the stability of the host country and the satisfaction level of the population and the government's response to these factors, the industry-specific factors focus on those factors which may make the industry a likely target for government action and also industry economic factors which give the perception the government is not reaping a large enough portion of the benefits from the industry.

One common occurrence during the time period studied was a price differential between the world price of copper

and the price realized from the studied projects. This originally occurred during World War II when there was a growing demand for copper for the war effort and a limited available supply. The U.S. government negotiated pacts with many copper producers (including Chile and Peru) that set the price of copper. This price stayed in affect long after the war ended and resulted in a price differential between the producer price and the London Metal Exchange (LME) price. The lower price resulted in lower government revenues for the host countries. The differential diminished in the 1970s when the producer price became much less important and most companies went to the LME price (or a close approximation). Today, a price differential probably would not be considered important, but for the time period of the study it should be included. A positive price differential is expected to have a positive relationship with the effective tax rate.

Reinvestment by the MNC in the host country is the next variable considered. Reinvestment in the country not only improves the economic development in the country, it also indicates to the government the level of interest the MNC has in the country. The higher the level of interest, the less government intervention is predicted.

The ratio of government revenues (from a project) to

MNC profits indicates the annual changes in the who-gets-what portion of the pie. This ratio is expected to have a negative effect on the effective tax rate. The larger the portion received by the government, the lower the effective tax rate is expected to be. If this ratio declines the host government is receiving a smaller percentage of revenues either through decreased government receipts or through increased MNC profits. Either one focuses on the project and the fact that the government is not receiving its "fair share."

The age of the project has been discussed in various ways as being an important determinant of political risk. Vernon discusses the obsolescing bargain and maintains that an MNC loses bargaining power over time. This "hostage" effect is caused by an MNC's inability to physically move an extractive project and therefore having to contend with the government of the country. The coefficient of this variable is expected to be positive.

Percentage of foreign ownership is considered an important factor in political risk. Projects 100 percent foreign owned are considered susceptible to higher political risk. In Chile, Anaconda received preferential tax treatment after it sold 51 percent of its projects to the Chilean government. Kennecott did not follow suit and

contended with higher tax rates. A positive correlation between foreign ownership and effective tax rate is expected.

In addition to the variables discussed above from the existing literature, a few other variables are considered in this study, as follows (the expected relationship to the dependent variable is given in parentheses):

- Agriculture as a Percentage of GDP (-)
- Investment as a Percentage of GDP (-)
- Annual Inflation Rate (+)
- Year Trend
- Project Dummy Variable
- Company Dummy Variable
- Country Dummy Variable

Both agriculture and investment as percentages of GDP are included in the study for reasons similar to those cited for manufacturing. They both give an indication of the diversity of the economy. In addition, agriculture may give an indication of the stability of the farming sector and the ability of a country to feed itself. Both the agricultural and investment ratios are expected to have a negative influence on the effective tax rate. Diversity in the economy lessens the chance of one industry being targeted by government action. And adequate domestic food supplies should increase the contentedness of the society, resulting in less chance of government actions against a

specific industry.

As discussed previously, the foreign exchange rate for the countries in this study would not adequately give the inflation rate because of fixed exchange rates over a several year period. Therefore the annual rate of inflation, defined by Gordon (1987) as the percentage rate of change of the implicit GNP deflator, is used. Inflation and the effective tax rate are expected to be positively correlated. Large inflation rates could bring a high level of discontent resulting in government actions.

A year trend is included to account for any world event which would affect all of the projects and is not accounted for by another specific variable.

The other variables included are dummy variables to distinguish projects, companies, and countries. As was discussed earlier, the country dummy is assumed to take into account the various social factors. The project dummy and company dummy may capture specific management traits or corporate philosophies which would induce a government to specific actions against a specific project or company. Table 3.4 summarizes the determinants, or independent variables, considered in the initial political risk model for this study.

The variables are regressed to determine their

influence on political risk. The type of regression used, the model, and the results are discussed in Chapter 4. The following section of this chapter discusses country choice

Table 3.4 Political Risk Determinants

1. Annual Percentage Change Per Capita GDP
2. Manufacturing/GDP
3. Foreign Trade Balance
4. Percentage Exports from Copper
5. Price Differential
6. Reinvestment from project
7. Government Revenues/MNC Profits Ratio
8. Agriculture as a Percentage of GDP
9. Investment as a Percentage of GDP
10. Annual Inflation Rate
11. Percent Foreign Ownership of Project
12 Year Trend
13. Tenure of Government
14. Campaign Year
15. Age of Project
16. Project Dummy Variable
17. Company Dummy Variable
18. Country Dummy Variable

criteria and gives a brief history for each country over the relevant time period. Data and data sources are discussed in the last section of this chapter.

Country Choices

Countries included in this study were chosen because (1) they have a history of American mining investment, (2)

mining accounts for 20 percent or more of GDP, (3) one mineral or metal has been dominant in the mining industry and has been responsible for a substantial percentage of total exports, (4) they are developing countries, and (5) data from individual projects is available. Using these criteria, Chile and Peru were selected. The period considered is from 1960 to 1987 or until nationalization or expropriation occurred.

Both Chile and Peru have long and colorful mining histories. The following gives a brief overview of each country's mining history and the fate of foreign mining investment. A complete discussion of Chile's copper mining history is found in Moran's (1974) and Ingram's (1974) works. The Peruvian copper history is well documented by Becker (1983).

Chile. Copper was first discovered in Chile at Chuquicamata at the beginning of the 16th century. Concern over foreign intervention and control of Chilean copper did not occur until the mid to late 1860s when British-owned smelters were accused in a newspaper article (in El Ferrocarril) of setting copper prices and thereby placing Chile in the situation of being "subjected to the interests of foreign speculators." This well predated the arrival of American companies in Chile in the early 1900s.

Concern with American influence in the copper industry began in the early 1920s, precipitated by the loss of domestically owned copper production. At the turn of the century, over 90 percent of copper production was controlled domestically. This fell to barely 10 percent (Ingram, 1974) by 1920. The reversal in ownership was brought about not only by the purchase of copper mines by American companies but also by a decline in copper prices which made many small Chilean-owned copper mines unprofitable. This, coupled with the emergence of the copper industry as a dominant economic force in the economy, resulted in increased nationalist attention to the copper industry and the foreign penetration of the industry. This dependence on foreign companies and markets resulted in a level of discontent.

Chilean discontent with foreign ownership of copper continued through the 1930s but had little financial effect on the MNCs until the mid-1940s. It is easiest to look at government actions during the 1900s in two parts: (1) the general tools employed by the government to increase its revenue from the foreign owned copper mines and (2) the Chilean government from 1950 to 1970 and its policies toward the foreign mining industry. The government historically has employed three instruments to increase its

revenues from copper production and to increase its control over the industry: (1) taxation, (2) exchange rates, and (3) marketing of the product.

Direct taxation of copper was initiated at less than 1 percent of the value of production in 1922 and increased to 12 percent by 1925. The Depression increased interest in the copper industry (as a revenue source) and the tax was increased to 18 percent in 1934. Another new tax (which almost doubled tax rates) was imposed in 1939 to finance CORFO (Corporacion de Fomento de la Produccion), whose purpose was to direct part of the economic surplus generated by the copper industry into the industrialization of Chile.

In 1937 the government further increased its revenues from copper production by imposing a frozen exchange rate for the Gran Mineria (comprised of the large foreign-owned mines) at 19.37 pesos to the dollar. When the tax rate was increased to 50 percent in 1942, the free market rate for the peso was 31.93 pesos per dollar, bringing the effective tax rate to 65 percent. The tax rate, increased to 60 percent in 1952, coupled with the fixed foreign exchange rate brought about an effective tax rate of 85 percent (Ingram, 1974).

In addition to the taxes and the fixed exchange rate

the Chilean government further increased government participation by becoming more involved with the marketing of copper.

Beginning in the early 1950s the governments of Chile proposed plans to end the foreign control of Chilean copper. In 1951 Carlos Ibanez was elected to the presidency on a platform of ending Chile's dependency on foreign companies in the copper industry. He was unsuccessful in his attempt to throw out the foreign interests and instead, in 1955, the Parliament passed the Nuevo Trato, or the "new deal."

The Nuevo Trato was the first attempt to establish a national copper policy in Chile. It tried to encourage the Gran Mineria to invest in new projects by promising higher profits. Taxes were levied on each company based on production levels. The fixed exchange rate was abolished, and new investment was given the incentive of increased depreciation allowances.

The Nuevo Trato failed when foreign companies did not respond to the incentives offered by the government. This reinforced the feeling of many Chileans that the copper industry depended too much on foreign capital and abilities. The attractiveness of nationalization gained during the years the Nuevo Trato was in effect.

President Eduardo Frei began the "chileanization" of the copper industry during 1964. This program was supposed to be run by "business decisions" but was also designed to increase the Chilean ownership of the major copper projects. The object was to have a profitable copper industry, of which the majority owner was the Chilean government. Frei was successful in chileanizing Kennecott's copper holdings. In 1968 Kennecott sold 51 percent of its El Teniente mine to the Chilean government.

Anaconda initially declined to sell the majority interest in its mines. The business environment continued to deteriorate for Anaconda and in 1969 it requested that, rather than selling majority interest, its holdings be expropriated. The Chilean government complied.

After Salvador Allende was elected president of Chile in 1970, he introduced legislation that completed nationalization of all foreign-held copper projects. Chile's mining history has been no less colorful since 1971. The national sentiment has swung from nationalization back to privatization of projects. This, however, will not be discussed in any detail as it does not directly affect the study.

Peru. Mining is and has been the linchpin of the

Peruvian economy, and copper is one of its most important mineral products. As was the case in Chile, the dominance of MNCs in the copper industry resulted in Peruvian economic dependence on a foreign entity. Copper became important to the Peruvian economy in the late 1800s and early 1900s when Peru lost its mineral nitrate deposits to Chile in the settlement that ended the War of the Pacific (1879-1883) and the Peruvian guano reserves were exhausted. Copper became one of most important exportable resources and retains that importance today.

Peru, like many developing countries, welcomed foreign investment in its mining industry. In 1901 a mining code was established to foster large-scale exploitation of copper by foreign investors. American foreign investments flowed into Peru from the Cerro Corporation in the early 1900s (Southern Peru Copper Company [SPCC] followed some fifty years later). Peru based its economic development on a "bonanza" policy; that is, the use of a specific resource to finance the state. In this case government revenues from the copper projects were supposed to finance government expenditures and serve as the cornerstone of economic development. The problem with this kind of development is that it is closely tied to the price of the commodity. When the price of copper was high, foreign

companies invested more in the country, and government revenues from the copper projects were high. When the world price was low, investments declined and government revenues were low. The 1950 Mining Code was enacted to liberalize foreign investment incentives. The major flaw in this code was that it failed to take into account the fluctuations in world copper prices and their effect on the Peruvian economy. These fluctuations resulted in good times and bad for the Peruvian government and the Peruvian people.

By 1960, the Peruvian economy was no longer benefiting from the liberal foreign investment incentives offered to the copper companies, and the country was growing more dissatisfied with the fluctuations associated with the ups and downs of the industry. The Peruvian government chose to tax the MNCs already in Peru at higher rates to increase government revenues and to receive a larger portion of the perceived profits. Even before the military coup of 1968, the MNCs felt the effects of the Peruvian government's philosophical change toward foreign-owned copper projects.

The military rule continued the "bonanza" development strategy with some modifications. It perceived the development of heavy industry as synonymous with economic development. To finance this development it continued the

bonanza strategy and drafted the 1971 mining code that increased state control over the MNC copper projects, including the creation of Minpeco which was given control over copper sales.

In 1975 a "coup-within-a-coup" traded one military leader for another. The change did little for foreign mining interests in Peru. In 1980, the military regime was replaced by an elected civilian government.

The new government replaced the 1971 mining code with the General Mining Law of 1981 which is, perhaps, more biased toward domestic mining projects. The state monopoly over export sales (given to Minpeco in 1971) was abolished. However, Minpeco retained its right to require the preferential sale of ores and concentrates to Peruvian refineries and it retained the right to impose its terms on the charges and dealings between producers and refiners. The 1981 mining law was the last major revision in the Peruvian handling of foreign mining ventures. Unlike Chile, Peru has not chosen to nationalize the industry. However, it has expropriated specific projects.

Data

The project data for the study is from five mines in Chile and Peru (Table 3.6). The three mines in Chile

include all the major American-owned copper mines which were nationalized in 1969 and 1971. The mines in Peru represent only the holdings of Southern Peru Copper Company which still owns and operates the mines. The Peruvian mining properties held by Cerro Corporation were expropriated in 1978. The parent company of Cerro was unwilling to contribute any information, and so the data set for Peru does not include all American-owned and operated copper mines. The difficulty in obtaining data for individual projects hampered the creation of the data set. The data set, comprised of 75 observation points is small by most standards. In some instances specific data points were not available. With the exception of the tax

Table 3.5 Selected Chilean and Peruvian Copper Mines

Mine	U.S. Ownership	Year Acquired	Country
Chuquicamata	Anaconda	1923	Chile
El Teniente	Kennecott	1915	Chile
El Salvador	Anaconda	1959	Chile
Toquepala	SPCC*	1960	Peru
Cuajone	SPCC	1977	Peru

* SPCC is owned by ASARCO, Marmon Group, Newmont Mining, and Phelps Dodge Overseas Capital Corporation.

rates for Kennecott's projects (which were estimated in

company reports) missing data values are recorded as such. Data for the Peruvian mines was obtained from the annual reports supplied by SPCC. The data for the Chilean mines was obtained from Moran's 1974 work, as well as Ingram's 1974 work.

Country data were obtained from the World Bank Data Tape (The World Bank, 1985), World Development Report (The World Bank, various years), and International Financial Statistics Yearbook (IMF, various years). Inflation rate is calculated from World Bank data. Data are included in Appendix A.

Chapter 4

METHODOLOGY AND REGRESSION RESULTS

Regression methods are an integral part of data analysis. Although the most popular regression model, ordinary least squares (OLS), is adequate for many types of analysis, it is limited in that the dependent variable is assumed to take on any value from negative to positive infinity. Consequently it is not adequate for this study because the dependent variable (as defined for this study) is continuous from negative to positive one but is truncated at these endpoints. Therefore a limited dependent variable model, or Tobit model (named after James Tobin (Tobin's Probit) who first introduced it to econometrics in 1958 for analyzing household expenditures on durable goods as a function of income and other variables) is employed. For a thorough discussion of limited dependent variable models the interested reader is referred, for example, to Maddala (1986) or the January 1984 issue of Journal of Econometrics.

Methodology

The Tobit model, truncated at both the high and low values can be expressed as

$$y^* = \beta' x + \epsilon \tag{4.1}$$

where y* is the dependent variable which is observable over a specified range. If the observed dependent variable is denoted by y, then

$$y = L_l \text{ if } y^* \leq L_l \tag{4.2}$$

$$= y^* \text{ if } L_l < y^* < L_u \tag{4.3}$$

$$= L_u \text{ if } y^* \leq L_u. \tag{4.4}$$

L_l and L_u, respectively, are the lower and upper limits of the dependent variable. In this study the regression is censored between negative (-1) and positive one (+1). This reflects the range within which the effective tax rate can vary. The largest annual increase that could possibly occur is from zero percent tax to 100 percent tax of gross profits (+1); conversely, the largest decrease possible would be from 100 percent to zero percent (-1) taxation of gross profits. Realistically, most observations will fall between these ranges rather than at the end points.

Although substantial developments have taken place in recent years in the estimation of different types of limited dependent variable models, there has been little

work on the effects of violating the different assumptions, checking the adequacy of the model assumed, and developing criteria for choosing between different models. These limitations should be noted when interpreting the results of this study. Unlike OLS, the Tobit model does not result in an R^2 statistic which represents the proportion of the variation in the dependent variable "explained" by the variation in the dependent variables. The "goodness of fit" for a Tobit model can be determined by the likelihood ratio index (LRI), given by

$$LRI = 1 - [L(\Omega)/L(\omega)], \tag{4.5}$$

where $L(\Omega)$ is the maximum value of the log-likelihood function, and

$L(\omega)$ is the maximum value of this function under the constraint that $\beta = 0$ for all β.

Obviously, $0 \leq LRI \leq 1$, and the better the fit, the closer the value of LRI will be to one. The LRI for dependent variable models will generally be lower than the R^2 statistic associated with a good explanatory regression in OLS. The importance of the independent variables on the dependent variable can be judged by the individual t-statistics, just as with OLS.

Because of lack of knowledge concerning functional

form for these model types, coupled with a relatively small data set, lag structures have not been used for any of the independent variables nor has an attempt been made to find an appropriate functional form. Rather a linear form is used, which does indicate the importance of individual variables and the overall goodness of fit of the model. This is adequate for testing the hypotheses that (1) political risk is influenced by measurable economic, political, and social factors, and (2) a measure of political risk can be quantified using appropriate regression analysis techniques and quantifiable independent variables.

The independent variables (referred to in Table 3.5) were regressed using a Tobit model. Three regressions were run to determine the effects of the three categories of dummy variables (country, company, and project). Variables that were not significant, or that were determined to be collinear were dropped from the model. The result is the model that best explains political risk as defined by this study.

The computational package used is LIMDEP. The algorithm is a form of the Davidon/Fletcher/Powell algorithm (LIMDEP Manual, p. 20.1). The basic algorithm is described in Maddala (1977, 173). Convergence is based on

any of three criteria: (1) gradient, (2) proportional change in all parameters, or (3) change in the function value.

Regression Results

The original regressions consisted of fourteen readily quantitative independent variables, four dummy variables, and a constant. The results for the regressions with the country and company data are presented in Table 4.1. The project regression encountered a problem with perfect multicollinearity when using the dummy variables with the other independent variables and is not presented. Regressions runs are included in Appendix B.

The annual inflation rate (INF) and annual percentage change in per capita GDP (GDP) are significant at the 5 percent level in both regressions (using a one-tailed t-test as the basis for this observation). The signs on the independent variables do not all influence the effective tax rate in the manner hypothesized in Chapter 3.

The goodness of fit, as determined by the LRI statistic, is approximately 71 percent for each regression. Even though this may seem low by traditional R^2 standards, for a limited dependent variable model this is a good indication of the validity of the hypothesis. The lack of

Table 4.1 Original Regression

Variable	Coefficient	T-ratio
A. With a country dummy variable		(LRI = 71 percent)
INF	.64706	2.409
REV	.00535	.549
REI	- .00611	- .628
PRC	- .00267	- .367
PA	- .00077	- .296
FO	.14641	.499
GDP	- .62852	-2.313
MIN	-4.45673	-1.503
GDI	-1.04594	-1.145
MAN	3.80996	1.364
AG	1.04419	1.143
CNE	.00000	- .619
CPE	- .48910	- .501
GT	- .01057	- .562
EY	.04832	.379
TT	- .01354	-1.116
CD	- .06541	- .125
ONE	- .31637	- .335
B. With company dummy variables		(LRI = 71 percent)
INF	.64586	2.403
REV	.00548	.559
REI	- .00624	- .638
PRC	- .00273	- .375
PA	- .00055	- .172
FO	.13876	.462
GDP	- .62741	-2.307
MIN	-4.12593	1.477
GDI	-1.05420	1.150
MAN	3.76703	1.338
AG	1.05234	1.149
CNE	- .00000	- .621
CPE	- .49404	- .506
GT	- .01054	- .560
EY	.04774	.375
TT	- .01377	-1.121
CMD1	- .04957	- .092
CMD2	.01632	.121
ONE	- .31548	- .334

(continued)

Table 4.1 (continued)

Where:

INF	=	annual inflation rate,
REV	=	government revenues/project profits ratio,
REI	=	company investment/project profits ratio,
PRC	=	price differential between producer price and the LME price of copper,
PA	=	project age,
FO	=	percent foreign ownership of the project,
GDP	=	annual percentage change in GDP per capita,
MIN	=	percentage GDP contributed by mining,
GDI	=	percentage GDP contributed by investment,
MAN	=	percentage GDP contributed by manufacturing,
AG	=	percentage GDP contributed by agriculture,
CNE	=	change in net exports (in US dollars),
CPE	=	percent of total exports contributed by copper,
GT	=	government tenure in office,
EY	=	election year dummy variable,
TT	=	time trend,
CD	=	country dummy variable,
CMD1	=	company dummy variable 1,
CMD2	=	company dummy variable 2, and
ONE	=	constant.

significance of individual variables, coupled with the goodness of fit indicates collinearity between variables. Collinearity was determined using the correlation coefficient calculated for each combination of independent variables. This coefficient measures the degree of the relationship between two random variables and ranges in value from (-1) to (+1).

Coefficient values close to either extreme indicate a high degree of relationship between the variables. High correlations (>|.7|) were found between MIN/GDI, REV/REI, and MAN/AG. Consequently, GDI, REV, and MAN were dropped from the model. MIN was included rather than GDI because of the interest this study has in the extractive industries. REI was retained rather than REV because from a forecasting standpoint it is easier for a company to estimate the percentage of profits it will reinvest rather than the revenue which will go to the government. AG was retained rather than MAN because of the self-sufficiency aspect of food supply and the potential contentment of the population which may be captured by AG and not by MAN. In addition to the highly correlated variables that were dropped, noncorrelated variables that were not significant at the 5 percent level, as indicated by the t-statistics, were dropped from the model. The results of the final

model are given in Table 4.2.

Table 4.2 Final Regression

Variable	Coefficient	T-ratio
INF	.302857	2.866
REI	-.000583	-3.272
GDP	-.278192	-2.431
MIN	-.301934	-2.856
AG	-.001726	-5.329
ONE	-.087314	-1.782

LRI = 65 percent

All of the independent variables, in the final regression, are significant at the 5 percent level. The LRI for the final model is slightly lower than that of the initial model. This is not surprising considering the independent variables that were dropped because of collinearity. Table 4.3 summarizes the significant explanatory variables and their relationship to the

Table 4.3 Significant Independent Variables

Variable	Relationship
Annual Inflation Rate (INF)	+
Annual Change in Per Capita GDP (GDP)	-
Reinvestment to Profits Ratio (REI)	-
Mining as a percentage of GDP (MIN)	-
Agriculture as a percentage of GDP (AG)	-

effective tax rate. The country-specific economic variables discussed in the previous chapter are, as a group, most significant. The annual percentage change in per capita GDP, the percentage of GDP contributed by both agriculture and mining, and the annual inflation rate are all significant. The positive relationship between per capita GDP and the annual change in the effective tax rate (CETR) indicates a developing country experiencing positive economic growth, on an annual basis, will not take negative action against a specific extractive project.

The negative relationship between MIN and CETR may seem counter-intuitive but what it indicates is the more important mining is to the economy, as a whole, the less the burden is shouldered by an individual project. This may not hold if there is no other mining industry outside of the copper industry. The negative relationship between AG and CETR can be interpreted as the larger percentage that agriculture contributes to GDP, the lower the effective tax rate will be for an individual mining. This indicates that self-production of an adequate food supply results in less discontent and consequently less need to tax a high profile industry. A more general interpretation for the results of MIN and AG may be the indication that a developing country with a broader based economy

(represented by the contributions to GDP by various sectors) will be less likely to place heavier tax burdens on a specific project. The above factors can be considered internal economic factors. None of the external economic factors were significant.

Political factors, as defined in this study, were not significant. Neither the tenure of the government nor an election year significantly contributed to a change in the effective tax rate. It could be argued that other qualitative political factors might have an influence. For reasons discussed previously, qualitative factors were excluded from this study.

Social factors, represented by the country dummy variable, did not prove significant. The use of one dummy variable to define all aspects unique to a specific country may be asking too much from the variable.

The only project-specific factor which is significant in this analysis is the percentage of profits from a project reinvested in the country. Somewhat surprisingly, the percentage of foreign ownership did not prove significant. The ratio of government revenues from the project to company profits would be significant in the regression if it were used without the reinvestment variable. The correlation between the two variables allows

the inclusion of only one of the variables. The reasons for including reinvestment were previously discussed. Reinvestment has a negative relationship with the change in the effective tax rate. Age of the project was not determined to be significant. The Tobit model estimated for this study resulted in a goodness of fit of 65 percent. This indicates, based on the definition of and the proxy used for political risk (the annual change in the effective tax rate), a correlation between political risk and determinants which are measurable and objective.

Other influences on the model may include the effects of important omitted variables, randomness in human response, or measurement error in the dependent variable. It is reasonable to assume that while all of these may contribute, omitted variables may be the major factor. As was discussed previously, social factors which may influence political risk were not included owing to lack of data. Furthermore, subjective quantitative and qualitative factors which may influence political risk were not included because of the desire to minimize bias.

Keeping in mind the possible qualitative and subjective quantitative factors which were not included, this study successfully demonstrates there are certain readily quantifiable economic factors (country and project)

which influence political risk. The cross-sectional, time-series nature of the data set coupled with the results indicates there are specific factors influencing political risk which transcend country borders.

The final regression analysis can be used to forecast the change in effective tax rate for a potential project, which is then incorporated into an optimal control model. This determines the optimal extraction path for the firm wanting to maximize the politically risk adjusted, net present value (NPV) of a project. A hypothetical project using this methodology is presented in Chapter 5. The politically risk adjusted NPV is then compared to the NPV which has not been adjusted for political risk.

Chapter 5

ECONOMIC EVALUATION

The third objective of this study is to incorporate political risk into an economic analysis for a potential project. There are several ways in which risk can be incorporated into economic analysis. Several of the more common methods are outlined below. For a more thorough discussion see Gocht, Zantop, and Eggert (1988) or Baumol (1977).

The first method of incorporating risk is to add a risk factor to the discount rate or, more specifically, to the cost of capital. A firm usually computes its average cost of capital by adding a weighted cost of equity with a weighted cost of debt (the relative weights are determined by the importance of each in the firm's optimal long-term financial structure [Etteman and Stonehill, 1986]). This weighted average cost of capital is used as the risk-adjusted discount rate for new projects which have the same general risk as existing projects. Foreign projects, with a political risk factor, would not be in the same risk category as similar domestic projects. Therefore, either the cost of capital has to be adjusted to include political risk or cash flows need to be adjusted.

Some may argue that the cost of capital factor, when calculated for a specific project, includes the political risk factor. However, if money is raised domestically for a foreign project, it may not include an adequate risk factor. Or if money is raised without a specific project targeted it is difficult to include an appropriate political risk factor. It could also be argued that, judging from past history, many MNCs did not do an adequate job of incorporating political risk into their cost of capital.

The second method of incorporating risk into an analysis is to adjust the future cash flows downward. This usually is done by reducing a risky future cash flow to its certainty equivalent, which is the smallest certain cash flow an investor is willing to exchange for the risky cash flow. This stream of certainty equivalents is then discounted by a risk free rate.

The third method is sensitivity analysis. This method recognizes a range of values for each variable and establishes a base, low, and high case for the analysis.

The fourth method for incorporating risk is the probability theory approach. This approach points out that a large number of alternative future outcomes (values) are possible. Each alternate payoff, at the pertinent future

date, must be considered along with its associated probability. The summation of each possible outcome times its probability (at a specific time) gives the expected outcome. The summation of the expected outcomes over the entire time horizon gives, in the case of present value, the expected net present value of the project.

The approach used in this study is closest to adjusting future cash flows. Rather than using a certainty equivalent, the future cash flows are reduced by the calculated effective tax rate. This example assumes a substantially different risk (specifically in the form of political risk) for the project which would not be included in the average cost of capital. Consequently, a risk premium (the effective tax rate) is included.

Therefore, instead of relying on the cost of capital to encompass all forms of risk, that risk (political) which can be forecast through other methods is added separately into the analysis. This should improve the accuracy of the analysis. Incorporating political risk into a cash flow analysis involves three steps. First, the regression equation estimated in Chapter 4 is used to forecast the change in the effective tax rate (the proxy for political risk). This forecast is then included in step two which uses an optimal control model to determine the optimal

extraction path for the project. Step three uses this extraction path to calculate the net present value of the project. The steps are detailed in the following sections.

To achieve the goals of this chapter a hypothetical project is assumed with the following parameters: (1) initial reserves of 1,000,000 pounds of copper of varying grade, (2) copper price is $1.00 per pound for the first year and increases 2 percent per year thereafter, (3) a perfectly competitive market, and (4) a 15 percent cost of capital. Exploration and development have been completed, and the question facing the firm is whether it should produce the mine or sell it prior to production. The goal of the firm is to maximize profits. It is assumed that the mine will have no value after production ceases. No constraints are placed on the project concerning annual production.

Effective Tax Rate

Forecasting the annual effective tax rate for a project requires an assumed beginning effective tax rate (τ). Also needed are forecasts for the inflation rate, annual change in per capita GDP, annual percentage of GDP contributed by mining and agriculture, and annual reinvestment over the relevant time period. These forecasts are incorporated

into the estimated regression from Chapter 4, resulting in the annual expected change in the effective tax rate. For the example, forecast numbers for each of the independent variables are assumed. These numbers are included in Appendix C. The effective tax rate used for year one of production is 40 percent. Effective tax rates for future years are determined by

$$\tau_t = \tau_{t-1} + \text{CETR}, \qquad (5.1)$$

where τ_t = the effective tax rate in time t,

τ_{t-1} = τ from the last time period, and

CETR = the change in τ, calculated from the regression results from Chapter 4.

Table 5.1 lists the values of τ, based on the above criteria. It is important to note that the forecasts for each of the independent variables should be a study in itself. The calculations of τ are part of a methodological example and are not determined from actual data.

The last column of Table 5.1 shows the effect of incorporating political risk into the effective tax rate. A company not considering such an effect could naively assume a constant effective tax rate of 40 percent. As will be shown later in this chapter, ignoring the political

Table 5.1 Effective Tax Rates

YEAR	CETR	τ^* (τ_{t-1} + CETR)
0	--	.400
1	.023	.423
2	.023	.447
3	.023	.469
4	.022	.493
5	.023	.515
6	.023	.538
7	.022	.560
8	.022	.583
9	.021	.604
10	.022	.627
11	-.007	.619
12	-.008	.611
13	-.008	.603
14	-.007	.595
15	-.008	.587
16	-.006	.581
17	-.005	.576
18	-.003	.573
19	-.002	.571
20	-.001	.569
21	.001	.570
22	.000	.570
:**	:	:
:	:	:
:	:	:
40	.000	.570

* Due to rounding, τ may appear not to equal τ_{t-1} + CETR.
** CETR for years 22 through 40 rounded to zero.

risk effect leads to a sub-optimal solution for the profit-maximizing firm. The annual effective tax rate can be incorporated into an optimal control model to determine the optimal extraction path.

Optimal Extraction Path

Because a nonrenewable resource is exhaustible, a profit-maximizing firm engaged in the extraction of an exhaustible resource must consider the opportunity cost involved in the extraction of the resource. This differs from production of an ordinary good where the profit maximizing production quantity is the point where marginal cost (MC) = marginal revenue (MR). The concept of depletable resources can be traced to the classical economists (i.e., Ricardo) but was first incorporated into modern theory by Hotelling (1931). The economic theory of depletable resources centers on the optimal production path which maximizes the discounted value of the project. The price of the commodity, the stock, the extraction costs, and user cost all are taken into account in defining the optimal extraction path. In this example, price and initial stock are given.

Fisher (1981, 24), Cairns (1990, 154), and others agree the cost of production increases (assuming constant

technology) over the production life of a mine (because of declining ore grades or accessibility). However, little empirical work has done specifying an operation cost function. It is generally agreed that extraction costs are a function of both the firm's output and its stock. That is

$$C = C(q_t, R_t), \tag{5.2}$$

where q_t = quantity extracted in time t,
R_t = remaining reserves in time t, and
t = the current time period.

For this example extraction costs are represented by

$$C = q^2_t / R_t . \tag{5.3}$$

This cost relationship represents the increasing cost of extraction as reserves are depleted. The problem for the firm is to maximize profits over the life of the project (see Conrad and Clark, 1987). This can be shown by

$$\underset{q_t}{\text{Max}}\ \Pi = \sum_{t=1}^{T} [(P_t q_t) - (q^2_t / R_t)][1/(1+r)^t](1-\tau_t) \tag{5.4}$$

subject to $R_{t+1} - R_t = -q_t$, (5.4a)

$R_0 = 1{,}000{,}000$, (5.4b)

$$R_T \geq 0, \text{ and} \qquad (5.4c)$$

$$T = 40, \qquad (5.4d)$$

where Π = profit,
T = terminal time,
P_t = price at time t,
$1/(1+r)^t$ = the discount factor,
r = cost of capital ,
t = the effective tax rate in time t and,
R_0 = the stock constraint.

The constraint $R_T \geq 0$ indicates that while no more than the original stock can be extracted, reserves can be left in the ground at the terminal time.

The net profit of extraction at any time is influenced by two factors: (1) revenues in the current period minus the costs (TR - TC), and (2) the impact on future profits from removing lower cost units of the resource (user cost). To account for this impact a Hamiltonian is employed giving the following

$$\mathcal{H} = (P_t q_t - q^2_t/R_t\ )[1/(1+r)^t\ ](1-\tau_t) - \lambda_{t+1}\ q_t, \qquad (5.5)$$

where λ_{t+1} = user cost at time t+1.

The necessary conditions are

i) $\partial\mathcal{H}/\partial q_t = (P_t - 2q_t/R_t)[1/(1+r)^t](1-\tau_t) - \lambda_{t+1} = 0,$

ii) $\dot{\lambda} = \lambda_{t+1} - \lambda_t = -\partial\mathcal{H}/\partial R_t = -1/(1+r)^t(q^2_t/R^2_t),$

iii) $R_{t+1} - R_t = -q_t,$

iv) $R_0 = 1{,}000{,}000,$ and

v) $\lambda_{T+1} = 0.$

Condition (v) assumes anything not extracted during the production life of the mine has no value after the terminal time (set at 40 years). Extending T farther into the future than needed allows the model to set the optimal extraction path without imposing time restrictions.

Condition (i) is solved for q_T/R_T, which is substituted into condition (ii) and solved for λ_T. This (λ_T) is then used to solve for q_{T-1}/R_{T-1} in condition (i). The iterative process is repeated until t=0. After q_0/R_0 is calculated, it is easy to solve for q_0, given R_0 = 1,000,000. From Eq. (5.4a) it follows that $R_{t+1} = R_t - q_t$. The optimal extraction path over the life of the mine is calculated similarly.

The optimal extraction path is calculated for both a varying effective tax rates and constant effective tax rate (Table 5.2). The intermediate values for λ_t, q_t, and R_t are given in Appendix D.

Table 5.2 shows the mine depletes within the 40-year

Table 5.2 Optimal Extraction Paths

Year	Varying ETR Pounds of Copper	Constant ETR Pounds of Copper
1	274,883	246,821
2	202,578	188,389
3	148,253	143,156
4	107,681	108,295
5	77,559	81,551
6	55,500	61,127
7	39,302	45,603
8	27,363	33,859
9	18,829	25,018
10	12,482	18,349
11	9,393	13,456
12	7,034	9,794
13	5,243	7,092
14	3,891	5,108
15	2,861	3,660
16	2,095	2,608
17	1,514	1,848
18	1,079	1,302
19	762	912
20	533	636
21	368	440
22	253	303
23	172	207
24	116	141
25	77	95
26	63	64
27	41	43
28	27	28
29	17	19
30	11	12
31	7	8
32	4	5
33	3	3
34	2	2
35	1	1
36	1	1
37	0	0
Cum. Prod.	1,000,000	1,000,000

period under either scenario. Incorporating the varying effective tax rate results in higher extraction during the first four years of production than under the constant effective tax rate. This is an intuitive result because if the risk is greater (i.e. higher taxes in the future) the firm will want to extract at a higher rate during initially. After the first four years of production the scenario which assumes a constant effective tax rate extracts at a slightly higher rate. Both scenarios deplete the mine in year 36 of production.

Although the Table 5.2 shows the different depletion paths for the two scenarios, it does not give a monetary comparison. The monetary comparison is a net present value (NPV) analysis which takes into account both the revenues received and the costs incurred to produce the mine. This NPV analysis is presented in the following section.

Net Present Value Comparisons

The NPV for the project is the summation of the annual profits discounted to today's dollars less sunk costs. That is

$$NPV = \sum_{t=1}^{T} (P_t q_t - q^2_t/Rt)[1/(1+r)^t (1-\tau_t) - F, \qquad (5.6)$$

where F = sunk costs (exploration and development costs).

All other notation is previously described.

Price is given as $1.00 per pound for the first year of production and increases 2 percent per year thereafter. R_t and q_t are taken from the optimal extraction model. The discount factor is 15 percent for the project. The values for τ_t are from Table 5.2 and sunk costs are assumed to equal $225,000, all spent prior to production.

NPV is calculated under two scenarios. The first assumes a varying τ and uses the corresponding extraction path. The second assumes τ constant (at 40 percent). The results for these scenarios are presented in Table 5.3. Annual profits under these scenarios are presented in Appendix E.

Table 5.3 gives the NPV results. If political risk (CETR) is not considered, this hypothetical example would be an attractive project. Incorporating the varying tax rates into the extraction path reduces NPV by 32 percent. A 32 percent decrease in profits may alter the firm's produce or sell decision.

Several points need to be made in concluding this chapter. First, the numbers used in this example are purely hypothetical and are used solely for the sake of example. Second, the values for τ have to be based on forecast data.

Table 5.3 Net Present Value (NPV)

Scenario	NPV
Varying τ/ Corresponding Extraction Path	$ 77,875
Constant τ/ Corresponding Extraction Path	$115,367

Third, and more importantly, extraction costs have to be modeled to determine a usable functional form. And fourth, a firm should require a sensitivity analysis to determine the range of possible outcomes rather than a single point estimate.

The example used is simplistic. It is intentionally framed in the short-run scenario to stay as straightforward as possible. Other needed constraints can be incorporated into the optimal control framework. These may include the long-run decision of optimal capital expenditure as well as maximum and minimum production rates. The model still results in the optimal extraction path (under the imposed constraints).

The purpose of this chapter, which is to present a hypothetical example incorporating political risk into economic analysis, is achieved. The methodology used is not new or unique. The only difference is incorporating an objective quantification of political risk into the

analysis. The implications for an extractive firm considering or not considering political risk can be seen in the comparison of the net present value calculations.

Chapter 6

CONCLUSIONS

Political risk should be of concern to any company considering a mining operation in a foreign country. History has proved there are risks involved. Most research in this area has focused on project-specific, qualitative factors. This does not allow a firm the opportunity to include political risk in its economic analyses. This study (not intending to discount the importance of some qualitative factors) concentrates on the readily quantifiable factors to reduce subjectivity and bias, and to allow for incorporation into economic analysis.

Objectives of the Study

This study has three objectives: 1) to identify the potential, readily quantifiable determinants of political risk in the extractive industries, 2) to test the hypotheses that political risk is influenced by these determinants and can be quantitatively analyzed, and 3) to demonstrate that quantitative analysis can be incorporated into an economic model used for mining investment decisions.

The first objective was achieved through a review of

the extant literature. Although many authors dwell on the qualitative aspects of political risk, several researchers have hypothesized about quantitative factors. The readily quantifiable determinants, drawn from the existing literature, were classified into country, industry, company, and project categories. The country variables were further broken into economic, political, and social factors.

The second objective was achieved by incorporating these determinants into a limited dependent variable regression (Tobit) model to test the hypotheses that political risk can be quantitatively analyzed. This required a measurable proxy for political risk. Keeping in mind the definition of political risk used in this study, (government actions which affect the profitability of a project) the annual change in the effective tax rate (CETR) for a specific project was used. The hypothesis was tested by using a cross-sectional, time-series data set composed of data from five individual mines, operated by three different firms in two countries. Three of the mines were nationalized; the other two are still private operations. Data from each mine covered the period from 1960 to 1987 or until the operation was nationalized.

The results of the regression indicate that political

risk (as defined by this study and for the data set employed) is influenced by certain quantifiable factors and can be quantifiably analyzed. The goodness-of-fit (65 percent) for the regression also indicates that all factors were not captured in the model. The most likely reasons for this are: (1) the exclusion of quantitative variables which influence political risk but are not directly (or in some cases indirectly) measurable, (2) exclusion of measurable social factors which may influence political risk but were not tested individually due to lack of data, and (3) dropping of variables affected by multicollinearity. The exclusion of qualitative and subjective quantitative variables was done intentionally to test the hypothesis of quantification and to minimize bias. Data for social variables were not available for the period in question.

The usual corrections for multicollinearity, add data or manipulate existing data, were not appropriate for this study mainly because (1) more data was not available and (2) the small size of the sample set made manipulations difficult. Although dropping variables that are correlated with other variables may not be the best method to correct for multicollinearity, it did result in giving the relative importance of remaining variables in the equation (at the

expense of the goodness of fit).

The third objective involved incorporating the regression results for CETR into economic analyses. The regression was used to forecast the effective tax rates (τ) over the life of a hypothetical project. The τ's were incorporated into an optimal control model determining the extraction path which maximized profits over the life of the mine. Using this depletion path, a politically risk-adjusted, net present value (NPV) was calculated. This was compared to the NPV for the same project without considering political risk. The example demonstrated the methodology for incorporating a political risk element into an economic analysis and also emphasized the monetary considerations.

The three objectives of this study were achieved in varying degrees. The potential quantitative determinants of political risk were determined mainly from the existing literature. The objective of proving the hypothesis that political risk can be quantitatively analyzed was also achieved within the realm of the data set used in the study. The quantitative analysis would be greatly enhanced by an expanded data set. The study also demonstrates that the quantitative representation of political risk can be incorporated into economic analyses.

Contributions

This research has contributed to the literature in two ways. First, it has extended the literature dealing with the determinants of political risk. Many of the readily quantifiable determinants, discussed in the extant literature, have been tested for their relationship to political risk. Of the fifteen determinants tested, five (rate of inflation, annual percentage change in per capita GDP, percentage of project profits reinvested annually, mining as a percentage of GDP, and agriculture as a percentage of GDP) were significant in the regression analysis. The cross-sectional nature of the data, coupled with the results of the regression, imply the assumption of project specificity of political risk needs to be reconsidered.

It should be noted that the validity of the above discussion depends upon the generality of the regression results. It would be ludicrous to argue that Chile and Peru are general enough cases to lend complete generality to the results. However, it can be argued that, for countries largely dependent upon the extractive industries for economic development, the regression (and results) can be considered general. Testing further generality of the model will require a larger, more diverse data set. This

is further discussed in the last section of the chapter.

The second contribution of this research is the methodology presented for incorporating political risk into economic analyses. This does not suggest that the regression results (from this study) be employed by any and every company. The appropriateness of this particular regression would have to be determined before incorporating it into an analysis. For example, it would not be appropriate to use these results for evaluating the economic potential of a project in Australia. As was discussed earlier, the generality of the results needs to be kept in mind.

Another contribution (although not to the literature) of this study is definition of future research topics. These are discussed in the following section.

Future Research

This study identified several potential research topics. These mainly involve the regression analysis and incorporation into an economic analysis.

The regression analysis was limited by the data set. The same type of analyses need to be carried out with an expanded data set. This set should include projects from developing and developed countries. It should also include

projects from countries where more than one mineral commodity is highly important. Incorporation of data from oil-producing countries would also test the stability of the model. This study was limited to U.S. firms. An expanded data set should include data from foreign firms. The difficult task in assimilating this type of data set is getting the project specific data that is necessary. Publicly owned firms tend to "hide" relevant data in their annual reports, and private firms have little impetus to share such data. Another problem in data collection is that some firms do not have historical data available.

If a larger data set could be collected it would allow testing the regression equation in this study to find out whether it holds over a larger, less homogenous sample set. A larger data set would also allow for research into the appropriate functional form which was not considered in this study.

A correct probability distribution for the regression needs to be developed. This would allow for the addition of probabilities of levels of political risk. These probabilities could be incorporated into the optimal control model and the NPV analysis giving an expected net present value and taking the work into the probability theory analysis discussed at the beginning of Chapter 5.

The optimal control model would be greatly enhanced by research concerning an appropriate extractive cost function. Cairns (1990) has presented a theoretical framework for the extractive cost function, but this needs to be incorporated on the empirical level in order for the optimal control approach to be widely used in industry (with or without the incorporation of political risk).

An area of study not included in this work deals with the financial aspect of looking at a project from the project perspective as well as the company perspective. Because of tax structure differences between the home and host countries and transaction and translation factors the profitability of a project may not be the same from the project viewpoint and the company viewpoint. An analysis incorporating political risk into both of these views would have to be carried out.

Political risk is alive and well, even though it may have appeared dormant in the 1980s. In light of the events of the last year it is imperative that firms consider political risk when evaluating foreign investment opportunities. To do this adequately, a framework is needed to allow a quantifiable political risk factor in economic analyses. This study has not answered all the questions, but it has presented the groundwork for a kind

of analysis that is necessary.

REFERENCES CITED

Baumol, W. J. 1977. Economic theory and operations analysis. 4th ed. Englewood Cliffs, N.J.: Prentice-Hall.

Becker, D. G. 1983. The new bourgeoisie and the limits of dependency. Princeton: Princeton University Press.

Brainard, L. J. 1981. Banker's Trust's approach to international risk assessment. In Assessing country risk. London: Euromoney Publications.

Bronfenbrenner, M. 1954-1955. The appeal of confiscation in economic development. Economic Development and Cultural Change. 3: 201-218.

Cairns, R. D. 1990. Geologic influences, metal prices and rationality. Resources and Energy 12 (July): 143-171.

Conrad, J. M., and C. W. Clark. 1987. Natural resource economics notes and problems. Cambridge: Cambridge University Press.

Daniel, Philip. 1989. Economic policy in mineral exporting countries: What have we learned? Golden, Colo.: Colorado School of Mines Working Paper 89-16.

Eitman, D. K., and A. I. Stonehill. 1986. Multinational business finance. 4th ed. Reading, Mass.: Addison-Wesley.

Fisher, A. C. 1981. Resource and environmental economics. Cambridge: Cambridge University Press.

Gocht, W. R.; H. Zantop; and R. G. Eggert. 1988. International mineral economics. New York: Springer-Verlag.

Gordon, R. J. 1987. Macroeconomics. 4th ed. Boston: Little, Brown and Company.

Green, R. T. 1974. Political structures as a predictor of radical political change. Columbia Journal of World Business. (Spring): 31-35.

Haendel, D. 1979. Foreign investment and the management of political risk. Boulder, Colo.: Westview Press.

Haner, F. T. 1981. Business environmental risk index, appendix b. BERI Ltd. System for Select Countries. (August): 9.

Hershbarger R. A. and J. P. Noerager. 1976. International risk management: Some peculiar constraints. Risk Management. (April): 23-34.

Hibbs, D. 1973. Mass political violence: A cross-national causal analysis. New York: John Wiley and Sons.

Hotelling, H. 1931. The economics of exhaustible resources. The Journal of Political Economy 39 (2): 137-175.

Ingram, G. M. 1974. Expropriation of U.S. property in South America: Nationalization of oil and copper companiesin Peru, Bolivia, and Chile. New York: Praeger.

Jodice, D. A. 1980. Sources of change in third world regimes for foreign direct investment, 1968-76. International Organization 34 (2): 177-206.

_____. 1985. Political risk assessment. Westport, Conn.: Greenwood Press.

Johnson, H. G. 1965. A theoretical model of economic nationalism in new and developing states. Political Studies Quarterly 80 (2): 169-185.

Kennedy, C. R. 1985. Political risk management: International lending and investing under environmental uncertainty. New York: Quorum Books.

Knudsen, H. 1974. Explaining the national propensity to expropriate: An ecological approach. Journal of International Business Studies. (Spring): 53-55.

Kobrin, S.J. 1979. Political risk: A review and reconsideration. Journal of International Business Studies 1 (Spring/Summer): 67-80.

_____. 1980. Foreign enterprise and forced divestment in the LDCs. International Organization 34 (Winter): 65-88.

Lax, H. L. 1983. Political risk in the international oil and gas industry. Boston: International Human Resources Development Corp.

_____. 1988. State and companies: Political risks in theinternational oil industry. New York: Praeger.

Maddala, G. S. 1977. Econometrics. New York: McGraw-Hill.

_____. 1986. Limited-dependent variables and qualitativevariables in econometrics. Cambridge: Cambridge University Press.

Mikesell, R. F. 1981. Options for packaging agreements to meet host government and foreign investor financial goals. Materials and Society 5 (4): 449-454.

Moran, T. H. 1974. Multinational corporations and the politics of dependence: Copper in Chile. Princeton, N.J.: Princeton University Press.

Nagy, P. 1981. Economic development, debt profiles, and country risk. In Assessing country risk. London: Euromoney Publications.

Raddock, D. M. 1986. Assessing corporate political risk. Totowa, N.J.: Rowman & Littlefield.

Ray, D. M. 1976. The causes of expropriation of american property abroad. Stanford Journal of International Studies. (Spring): 122-152.

Robock, S. H. 1971. "Political risk: Identification and assessment." Columbia Journal of World Business July/ August: 6-20.

Root, F. R., and A. A. Ahmed. 1979. Empirical determinants of manufacturing direct foreign investment in developing countries. Economic and Cultural Change 27 (July): 751-767.

Stobaugh, R. 1969. Where in the world should we put that plant? Harvard Business Review 47 (1):

Vernon, R. 1971. Sovereignty at Bay. New York: Basic Books.

ADDITIONAL READINGS

Bennet, P. D., and R. Green. 1972. Political insatability as a determinant of dfi. Journal of Marketing Research. May: 182-186.

Bergne, D. J. 1982. Political risk analysis: An assest now, soon a must. Public Relations Quarterly. Summer: 28-31.

Brainard, L. J. 1981. Banker's trust's approach to international risk assessment. in Assessing country risk. London: Euromoney Publications Limited.

Brewer, T. L. 1981. Political risk assessment for foreign direct investment decisions: Better methods for better results. Columbia Journal of World Business. Spring: 5-11.

Chevalier. A., and G. Hirsch. 1981. The assessment of the political risk in the investment decision. Journal of the Operational Research Society 32(7): 599-610.

De Geoffroy, J. G., and T. K. Wignall. 1985. Designing optimal strategies for mineral exploration. New York: Plenum Press.

Eaton, J., and S. J. Turnovsky. 1983. Exchange risk, political risk, and macroeconomic equilibrium. American Economic Review 73(3): 183-189.

Euromoney Publications Limited, 1981. Assessing country risk. London: Euromoney Publications.

Fortin, C. 1984. Copper investment in Chile 1973-1984. Natural Resources Forum 8(4): 315-325.

Gadar, F., and T. H. Moran. 1984. International political risk management: New dimensions. Washington D. C.: Gadar and Associates.

Garnaut, R., and A. C. Ross. 1983. Taxation of mineral rents. Oxford: Clarendon Press.

Jackman, R. 1982. Dependence on foreign investment and economic growth in the third world. World Politics 34(2): 175-196.

Johnson, C. J. 1981. Taking the take but not the risk. Materials and Science 5(4): 455-469.

Jones, R. J. 1980. A model for predicting expropriation in Latin America applied to Jamaica." Columbia Journal of World Business. Spring: 74-80.

Kahler, M. 1981. Political regime and economic actors: The response to firms to the end of colonial rule. World Politics 33(3): 383-412.

Kobrin, S. J. 1978. When does political instability result in increased investment risk? Columbia Journal of World Business. Fall: 113-122.

_____. 1987. Testing the bargaining hypothesis in the manufacturing sector in developing countries. International Organization 41(4): 609-638.

Merrill, A. T. 1982. Chile: A country study. Washington D. C.: American University.

Mikesell, R. F. 1987. The world mining industry. Boston: Allen and Unwin.

Moran, T. H., ed. 1980. International political risk assessment: The state of the art. Washington, D.C.: School of Foreign Service, Georgetown University Press.

_____. 1989. Mining companies, economic nationalism, and third world development in the 1990s: Deja vu all over again? Golden, Colo.: Colorado School of Mines Working Paper 89-5.

Parry, T. G. 1980. The multinational enterprise: International investment and host-country impacts. Greenwich, Conn.: JAI Press.

Prast, W. G., and H. L. Lax. 1982. Political risk as a variable in the TNC decision-making. Natural Resources Forum 6: 183-199.

Skocpol, T. 1979. States and social revolutions. Cambridge: Cambridge University Press.

Ting, W. 1988. Multinational risk assessment and management. Westport, Conn.: Greenwood Press.

Todaro, M. P. 1985. Economic development in the third world. 3rd ed. New York: Longman.

United States Embassy Santiago. 1989. Chile industrial outlook report: Minerals. Santiago, Chile: Embassy of the United States.

APPENDIX A

DATA

Source of all Peruvian mine data is Southern Peruvian Copper Corporation's annual reports from various years.

Touquepala Mine - Peru

YEAR	TAX RATE	GOVERNMENT REVENUES	COMPANY PROFITS
	Percent	Millions of Dollars	Millions of Dollars
1960	N.A.	N.A.	N.A.
1961	0.1753	5.31	24.99
1962	0.1442	4.72	17.26
1963	0.1698	4.01	19.62
1964	0.1733	4.72	22.75
1965	0.2252	9.15	31.46
1966	0.2625	21.44	60.23
1967	0.4057	32.17	47.13
1968	0.3690	32.36	55.34
1969	0.4498	53.67	65.65
1970	0.6231	61.90	37.43
1971	0.5673	34.48	26.21
1972	0.4966	26.55	26.91
1973	0.5393	73.29	61.32
1974	0.5378	50.40	40.48
1975	1.0000	8.30	- 9.60
1976	0.7747	23.43	8.35
1977	0.8671	31.50	19.30
1978	0.6489	22.00	11.90
1979	0.7794	104.60	29.20
1980	0.8458	116.80	19.30
1981	0.8308	38.80	8.40
1982	0.6741	16.40	- 2.90
1983	0.4817	7.90	- 0.30
1984	0.4244	8.70	11.60
1985	1.0000	15.00	- 5.20
1986	0.5652	3.50	- 9.30
1987	0.8387	4.30	0.80

Toquepala Mine - Peru

YEAR	REINVEST-MENT	AGE OF PROJECT	PERCENT FOREIGN OWNERSHIP
	Millions of Dollars	Number of Years	
1960	N.A.	1	100.00
1961	24.99	2	100.00
1962	17.26	3	100.00
1963	0.00	4	100.00
1964	22.75	5	100.00
1965	6.46	6	100.00
1966	20.47	7	100.00
1967	1.75	8	100.00
1968	5.27	9	100.00
1969	3.10	10	100.00
1970	2.22	11	100.00
1971	0.00	12	100.00
1972	11.27	13	100.00
1973	61.32	14	100.00
1974	40.48	15	100.00
1975	0.00	16	100.00
1976	8.35	17	100.00
1977	19.30	18	100.00
1978	11.90	19	100.00
1979	27.30	20	100.00
1980	19.30	21	100.00
1981	8.40	22	100.00
1982	0.00	23	100.00
1983	0.00	24	100.00
1984	11.60	25	100.00
1985	0.00	26	100.00
1986	0.00	27	100.00
1987	0.80	28	100.00

Cuajone Mine - Peru

YEAR	TAX RATE	GOVERNMENT REVENUES	COMPANY PROFITS
		Millions of Dollars	Millions of Dollars
1977	0.0000	0.00	-10.30
1978	0.5410	25.90	18.00
1979	0.4136	75.40	98.00
1980	0.3862	52.40	62.40
1981	0.3384	9.00	11.70
1982	0.0000	0.00	- 0.90
1983	0.0000	0.00	10.40
1984	0.0000	0.00	- 6.30
1985	1.0000	3.30	-15.50
1986	0.0000	0.00	- 7.40
1987	1.0000	33.70	- 3.40

Cuajone Mine - Peru

YEAR	REINVEST-MENT	AGE OF PROJECT	PERCENT FOREIGN OWNERSHIP
	Millions of Dollars	Number of Years	
1977	0.00	1	100.00
1978	18.00	2	100.00
1979	98.00	3	100.00
1980	20.00	4	100.00
1981	0.00	5	100.00
1982	0.00	6	100.00
1983	10.40	7	100.00
1984	0.00	8	100.00
1985	0.00	9	100.00
1986	0.00	10	100.00
1987	0.00	11	100.00

Source for all Chilean mine data is Moran, T. H. 1974. Multinational Corporations and the Politics of Dependence: Copper in Chile. Princeton: Princeton University Press.

El Salvador - Chile

YEAR	TAX RATE	GOVERNMENT REVENUES	COMPANY PROFITS
		Millions of Dollars	Millions of Dollars
1960	0.0270	0.07	2.69
1961	0.0000	0.00	0.60
1962	0.0000	0.00	2.13
1963	0.0860	1.29	3.63
1964	0.7600	2.87	0.91
1965	0.5200	3.55	3.28
1966	1.0000	10.56	- 1.88
1967	0.6040	17.99	19.21
1968	0.4860	23.61	25.01
1969	1.0000*	31.07	0.00

* Mine expropriated

El Salvador - Chile

YEAR	REINVEST-MENT	AGE OF PROJECT	PERCENT FOREIGN OWNERSHIP
	Millions of Dollars	Number of Years	
1960	2.69	3	100.00
1961	0.60	4	100.00
1962	1.33	5	100.00
1963	3.63	6	100.00
1964	0.91	7	100.00
1965	3.27	8	100.00
1966	0.00	9	100.00
1967	6.92	10	100.00
1968	10.61	11	100.00
1969	N.A.	12	0.00

El Teniente - Chile

YEAR	TAX RATE	GOVERNMENT REVENUES	COMPANY PROFITS
		Millions of Dollars	Millions of Dollars
1960	0.6930	53.67	23.75
1961	0.8080	39.15	9.28
1962	0.7850	36.90	10.09
1963	0.8570	38.32	6.41
1964	0.7880	47.77	12.90
1965	0.8610	52.90	8.52
1966	0.8030	89.50	22.15
1967	0.4400	28.29	82.43
1968	0.4400	9.62	78.30
1969	0.4400	34.77	60.00
1970	0.4400*	34.77	50.00
1971	1.0000**	N.A.	N.A.

* Estimated from company reports
** Mine expropriated

El Teniente - Chile

YEAR	REINVEST-MENT	AGE OF PROJECT	PERCENT FOREIGN OWNERSHIP
	Millions of Dollars	Number of Years	
1960	2.94	45	100.00
1961	9.91	46	100.00
1962	4.79	47	100.00
1963	4.44	46	100.00
1964	5.23	49	100.00
1965	5.56	50	100.00
1966	2.61	51	100.00
1967	19.64	52	49.00
1968	78.23	53	49.00
1969	60.00	54	49.00
1970	50.00	55	49.00
1971	N.A.	56	0.00

Chuquicamata Mine - Chile

YEAR	TAX RATE	GOVERNMENT REVENUES	COMPANY PROFITS
		Millions of Dollars	Millions of Dollars
1960	0.6170	34.42	21.36
1961	0.5690	33.72	25.53
1962	0.6270	52.45	31.24
1963	0.6160	46.79	29.26
1964	0.6140	54.48	34.31
1965	0.6850	69.89	32.98
1966	0.6130	96.63	61.62
1967	0.5830	102.03	72.90
1968	0.4400*	98.54	73.80
1969	1.0000**	149.89	0.00

* Estimated from company reports
** Mine expropriated

Chuquicamata Mine - Chile

YEAR	REINVEST-MENT	AGE OF PROJECT	PERCENT FOREIGN OWNERSHIP
	Millions of Dollars	Number of Years	
1960	10.08	37	100.00
1961	5.57	38	100.00
1962	8.46	39	100.00
1963	9.81	40	100.00
1964	7.21	41	100.00
1965	9.00	42	100.00
1966	22.59	43	100.00
1967	43.61	44	100.00
1968	62.32	45	100.00
1969	N.A.	46	0.00

Copper Prices

YEAR	L.M.E. PRICE *	PERU PRICE **	CHILE PRICE ***
	Cents per pound	Cents per pound	Cents per pound
1960	30.72	29.00	32.08
1961	28.72	28.45	29.95
1962	29.22	29.02	30.63
1963	29.31	28.97	30.63
1964	43.92	31.31	31.99
1965	58.53	36.33	35.03
1966	69.42	53.88	36.16
1967	51.63	48.11	38.25
1968	56.31	49.40	41.88
1969	66.52	66.85	47.55
1970	64.11	55.77	57.71
1971	49.00	47.72	51.45
1972	48.59	45.80	
1973	81.04	87.29	
1974	93.42	80.40	
1975	56.13	54.00	
1976	63.57	59.40	
1977	59.39	56.60	
1978	61.93	61.40	
1979	90.06	62.50	
1980	99.04	96.00	
1981	79.04	76.60	
1982	67.15	65.90	
1983	72.23	71.00	
1984	62.57	62.00	
1985	64.29	64.10	
1986	62.34	62.10	
1987	81.00	81.30	

* From Metals Week. Various issues.
** From Southern Peruvian Copper Corporation. Annual Report. Various Years.
*** From Moran, T. H. (1974).

Peru - Country Data

YEAR	INVESTMENT GDP RATIO *	AGRICULTURE GDP RATIO *	PERCENT COPPER OF EXPORTS **
1960	0.2364	0.1804	0.2500
1961	0.2373	0.1764	0.2300
1962	0.2371	0.1698	0.1300
1963	0.2414	0.1666	0.1300
1964	0.2424	0.1672	0.1700
1965	0.2462	0.1592	0.1700
1966	0.2447	0.1565	0.2400
1967	0.2451	0.1582	0.2400
1968	0.2489	0.1532	0.2600
1969	0.2425	0.1545	0.2900
1970	0.2488	0.1609	0.2400
1971	0.2525	0.1516	0.2000
1972	0.2505	0.3850	0.1900
1973	0.2531	0.1302	0.2700
1974	0.2512	0.1251	0.2200
1975	0.2506	0.1203	0.1200
1976	0.2547	0.1206	0.1700
1977	0.2493	0.1192	0.2300
1978	0.2387	0.1185	0.2100
1979	0.2349	0.1168	0.1900
1980	0.2377	0.1046	0.1900
1981	0.2292	0.1093	0.1600
1982	0.2263	0.1122	0.1400
1983	0.2119	0.1142	0.1400
1984	0.2117	0.1229	0.1300
1985	0.2164	0.1245	0.1600
1986	N.A.	0.1169	0.1800
1987	N.A.	N.A.	0.1800

* From World Bank Data Tapes
** From International Financial Statistics. Various Years.

Peru - Country Data

YEAR	PER CAPITA GDP	MANUFACTURING GDP RATIO	MINING GDP RATIO
	Local Currency		
1960	155.73	0.4453	0.1032
1961	162.24	0.4183	0.1051
1962	170.57	0.4070	0.0923
1963	171.68	0.3789	0.0946
1964	177.60	0.3843	0.0932
1965	180.86	0.4101	0.0902
1966	190.87	0.4532	0.0913
1967	192.86	0.4268	0.0891
1968	188.45	0.2980	0.0943
1969	190.46	0.2965	0.0902
1970	195.77	0.2686	0.0912
1971	198.22	0.2436	0.0823
1972	198.27	0.1632	0.0850
1973	203.10	0.2856	0.0837
1974	215.68	0.3680	0.0809
1975	216.77	0.3389	0.0722
1976	215.98	0.2900	0.0750
1977	211.99	0.2154	0.0703
1978	207.72	0.1845	0.1182
1979	214.83	0.2168	0.1315
1980	219.37	0.2827	0.1285
1981	223.58	0.3262	0.1193
1982	218.99	0.3020	0.1205
1983	187.60	0.2077	0.1240
1984	190.82	0.1823	0.1245
1985	189.04	0.1370	0.1278
1986	199.56	0.1332	N.A.
1987	200.87	N.A.	N.A.

From World Bank Data Tapes

Peru - Country Data

YEAR	RATE OF INFLATION *	GOVERNMENT TENURE **	CAMPAIGN YEAR **
1960	N.A.	5	0
1961	0.0740	6	0
1962	0.0350	1	1
1963	0.0330	1	1
1964	0.1610	2	0
1965	0.1110	3	0
1966	0.1250	4	0
1967	0.1110	5	0
1968	0.1800	1	1
1969	0.0680	2	0
1970	0.0790	3	0
1971	0.0440	4	0
1972	0.0560	5	0
1973	0.1470	6	0
1974	0.1630	7	0
1975	0.2000	8	0
1976	0.3500	9	0
1977	0.3830	10	0
1978	0.6160	11	0
1979	0.7850	12	0
1980	0.5480	1	1
1981	0.6630	2	0
1982	0.6500	3	0
1983	1.1100	4	0
1984	1.1700	5	0
1985	1.6000	6	0
1986	N.A.	1	1
1987	N.A.	2	0

* Calculated from World Bank Data Tapes.
** From Ingram, G. M. (1974) and Becker, D. G. (1983).

Chile - Country Data

YEAR	PER CAPITA GDP	MANUFACTURING GDP RATIO	MINING GDP RATIO
	Local Currency		
1960	24667.15	0.1463	0.0771
1961	25231.38	0.1583	0.0809
1962	25812.48	0.1396	0.0834
1963	26821.58	0.1573	0.0793
1964	26809.10	0.1852	0.0824
1965	26438.35	0.1794	0.0747
1966	28804.34	0.2311	0.0700
1967	29165.07	0.2029	0.0694
1968	29633.40	0.2124	0.0700
1969	30161.28	0.2201	0.0691
1970	30219.55	0.2336	0.0657
1971	32315.26	0.2076	0.0639

From World Bank Data Tapes

Chile - Country Data

YEAR	INVESTMENT GDP RATIO *	AGRICULTURE GDP RATIO *	PERCENT COPPER OF EXPORTS **
1960	0.2226	0.1062	0.7000
1961	0.2282	0.0995	0.6700
1962	0.2385	0.0907	0.6900
1963	0.2331	0.0906	0.7200
1964	0.2396	0.0898	0.7400
1965	0.2482	0.0900	0.7900
1966	0.2514	0.0979	0.8400
1967	0.2505	0.0975	0.7700
1968	0.2496	0.0989	0.8000
1969	0.2471	0.0841	0.8600
1970	0.2470	0.0850	0.6700
1971	0.2574	0.0772	0.7000

* From World Bank Data Tapes
** From International Financial Statistics.

Chile - Country Data

YEAR	RATE OF INFLATION *	GOVERNMENT TENURE **	CAMPAIGN YEAR **
1960	N.A.	3	0
1961	0.0650	4	0
1962	0.1340	5	0
1963	0.4360	6	0
1964	0.4730	1	1
1965	0.3930	2	0
1966	0.2860	3	0
1967	0.2560	4	0
1968	0.3390	5	0
1969	0.3980	6	0
1970	0.4060	1	1
1971	0.1850	2	0

* Calculated from World Bank Data Tapes.
** From Ingram, G. M. (1974).

APPENDIX B

REGRESSION RESULTS

Initial Regression With Country Dummy Variable

Limited Dependent Variable Model - CENSORED Regression
Threshold Values -- Variable Constant
Lower ONE -1.000
Upper ONE 1.000
(Limit = variable times constant; **** = - or + infinity)

<< Least Squares Regression >>

Dependent Variable	X43	Number of Observations	75
Mean of Dep. Var.	-79.874896	Std. Dev. of Dep. Var.	272.860562
Std. Error of Regr.	170.773224	Sum of Sqrd. Residuals	1662319.157930
R - squared	.698282	Adjusted R - Squared	.608296

Variable	Coefficient	Std. Error	T-ratio	Prob|t|≥x	Mean of X	Std.D.of X
INF	-34.2377	155.457	-.220	.82568	-106.20	310.58
REV	1.36711	5.81967	.235	.81428	-52.618	226.18
REI	-1.43691	5.81187	-.247	.80472	-52.771	226.11
PRC	-2.64534	4.37252	-.605	.54518	-5.9979	9.3286
PA	1.02049	1.50397	.679	.49743	22.533	17.901
FO	111.929	163.467	.685	.49352	.90560	.24419
GDP	35.1773	155.474	.226	.82100	-53.257	225.99
MIN	-313.716	1780.30	-.176	.86012	-53.195	226.00
GDI	-225.256	522.143	-.431	.66617	-26.412	162.07
MAN	348.041	1676.78	.208	.83557	-53.053	226.04
AG	225.250	522.134	.431	.66618	-26.530	162.05
CNE	-.391613E-08	.124955E-07	-.313	.75397	-.67001E+08	.17231E+10
CPE	-476.181	574.692	-.829	.40734	.45613	.28538
GT	-12.5907	10.9664	-1.148	.25092	4.1600	2.7804
EY	-2.54983	74.7007	-.034	.97277	.17333	.38108
TT	8.18410	7.04875	1.161	.24561	11.907	8.1873
CD	-317.025	307.582	-1.031	.30268	.52000	.50296
ONE	153.290	539.362	.284	.77625	1.0000	.00000

Method=NEWTON; Maximum iterations = 25

Convergence criteria:	Gradient =	.1000000E-01			
	Function =	.1000000E-01			
	Parameters=	.1000000E-01			
Starting values:	-.2005	.8005E-02	-.8414E-02	-.1549E-01	.5976E-02
	.6554	.2060	-1.837	-1.319	2.038
	1.319	-.2293E-10	-2.788	-.7373E-01	-.1493E-01
	.4792E-01	-1.856	.8976	.5856E-02	

```
==> NEWTON Iterations

Iteration  1     Function    406.8690
Param    -.200      .801E-02 -.841E-02 -.155E-01  .598E-02  .655       .206
         -1.84     -1.32      2.04      1.32     -.229E-10 -2.79      -.737E-01
         -.149E-01  .479E-01 -1.86      .898      .586E-02
Gradnt   -61.2     -578.     -588.      12.4     -43.2     -9.84      -.838E-01
         -58.7      755.     -60.1      756.     -.863E+09 -2.47      -78.0
          .816     -114.     -9.26     -9.84     -.113E+05

Iteration  2     Function    357.0558
Param     .227     -.216E-02  .217E-02 -.699E-03  .310E-03  .167E-01 -.219
         -1.80     -.529      1.57      .528     -.763E-11 -.359      -.154E-01
         -.364E-01 -.960E-03 -.143      .517E-01  .117E-01
Gradnt    18.1      .445      .176     -.193      .140      .208      -.528E-01
          18.1      41.9      18.2      41.8      .373E+08  .492E-01   1.48
          .237E-01  .488      .208      .208     -.563E+04

Iteration  3     Function    311.3464
Param     .215     -.230E-02  .231E-02 -.132E-02  .351E-03  .358E-01 -.206
         -2.13     -.679      1.92      .678     -.965E-11 -.487      -.169E-01
         -.317E-01  .154E-02 -.218      .708E-01  .234E-01
Gradnt   -.230E-01 -.155E-01 -.160E-01 -.124E-03  .147E-02  .328E-03 -.635E-01
          .405E-01  .695E-01  .406E-01  .694E-01  .569E+05  .100E-03  .202E-02
          .289E-04 -.187E-03  .281E-03  .328E-03 -.282E+04

Iteration  4     Function    265.6907
Param     .228     -.217E-02  .215E-02 -.136E-02  .328E-03  .389E-01 -.218
         -2.22     -.697      1.99      .696     -.986E-11 -.493      -.170E-01
         -.302E-01  .118E-02 -.217      .613E-01  .468E-01
Gradnt   -.481E-01 -.162E-01 -.164E-01 -.164E-03  .123E-02  .147E-03 -.663E-01
          .182E-01  .198E-01  .182E-01  .197E-01  .105E+05  .598E-04  .105E-02
          .150E-05  .370E-03  .970E-04  .147E-03 -.141E+04

Iteration  5     Function    220.1383
Param     .255     -.189E-02  .184E-02 -.145E-02  .283E-03  .451E-01 -.243
         -2.39     -.732      2.14      .731     -.103E-10 -.504      -.171E-01
         -.271E-01  .475E-03 -.214      .428E-01  .935E-01
Gradnt    .513E-03 -.168E-01 -.175E-01 -.753E-03  .740E-03  .387E-03 -.720E-01
          .726E-01  .787E-01  .726E-01  .786E-01  .415E+05  .124E-03  .348E-02
          .602E-05  .120E-02  .333E-03  .387E-03 -703.

Iteration  6     Function    174.8251
Param     .309     -.133E-02  .120E-02 -.163E-02  .192E-03  .574E-01 -.294
         -2.74     -.804      2.43      .802     -.111E-10 -.527      -.173E-01
         -.211E-01 -.932E-03 -.209      .630E-02  .187
Gradnt    .199     -.170E-01 -.195E-01 -.300E-02 -.142E-02  .128E-02 -.835E-01
          .282      .306      .283      .306      .160E+06  .360E-03  .126E-01
          .237E-04  .411E-02  .122E-02  .128E-02 -350.
```

```
Iteration  7     Function    130.1208
Param     .416      -.209E-03 -.578E-04 -.199E-02  .145E-04  .820E-01 -.398
         -3.42      -.947      3.00       .945     -.128E-10 -.575     -.178E-01
         -.933E-02 -.370E-02 -.199      -.646E-01  .371
Gradnt    .955      -.132E-01 -.227E-01 -.110E-01 -.101E-01  .441E-02 -.106
          1.06       1.16      1.06       1.15      .588E+06  .118E-02  .450E-01
          .920E-04  .127E-01  .433E-02  .441E-02 -174.

Iteration  8     Function    87.13043
Param     .624       .197E-02 -.252E-02 -.274E-02 -.322E-03  .130      -.602
         -4.76      -1.23      4.14       1.23     -.161E-10 -.677     -.190E-01
          .131E-01 -.900E-02 -.186      -.198       .731
Gradnt   3.54        .695E-02 -.266E-01 -.359E-01 -.422E-01  .137E-01 -.152
         3.69       4.04      3.69       4.03      .195E+07  .367E-02  .144
         .340E-03  .259E-01  .136E-01  .137E-01 -84.8

Iteration  9     Function    49.21279
Param     1.01       .600E-02 -.706E-02 -.419E-02 -.916E-03  .220      -.982
         -7.27      -1.78      6.26       1.77     -.226E-10 -.887     -.221E-01
          .529E-01 -.185E-01 -.176      -.432       1.39
Gradnt   10.2        .665E-01 -.315E-01 -.886E-01 -.135      .316E-01 -.237
         10.5       11.6      10.5       11.6      .504E+07  .867E-02  .346
         .110E-02 -.177E-01  .315E-01  .316E-01 -38.8

Iteration 10     Function    24.23390
Param     1.60       .121E-01 -.139E-01 -.657E-02 -.178E-02  .359     -1.57
         -11.2      -2.65      9.57       2.64     -.331E-10 -1.25     -.283E-01
          .110      -.325E-01 -.187      -.765       2.40
Gradnt   17.0        .120      -.528E-01 -.119      -.253     .366E-01 -.370
         17.4       19.7      17.4       19.7      .728E+07  .108E-01  .439
         .233E-02 -.234       .363E-01  .366E-01 -14.3

Iteration 11     Function    17.06286
Param     2.13       .174E-01 -.199E-01 -.878E-02 -.251E-02  .482     -2.08
         -14.7      -3.46      12.6       3.45     -.428E-10 -1.62     -.351E-01
          .158      -.445E-01 -.219      -1.04       3.28
Gradnt   8.05        -.122E-01 -.104      -.464E-01 -.133     .113E-01 -.491
         8.55       10.1      8.55       10.1      .314E+07  .392E-02  .158
         .159E-02 -.211       .109E-01  .113E-01 -2.67

Iteration 12     Function    16.71647
Param     2.28       .189E-01 -.216E-01 -.941E-02 -.272E-02  .517     -2.22
         -15.7      -3.69      13.4       3.69     -.456E-10 -1.73     -.373E-01
          .171      -.478E-01 -.232      -1.12       3.53
Gradnt  -.579E-01 -.124      -.129      -.230E-02  .303E-02  .104E-02 -.526
          .469       .579      .469       .579      .161E+06  .494E-03  .101E-01
         .110E-03 -.118E-01  .648E-03  .104E-02 -.102
** B-vector has converged.
```

Maximum Likelihood Estimates

Log-Likelihood..... -16.716

Variable	Coefficient	Std. Error	T-ratio	Prob|t|≥x	Mean of X	Std.D.of X
INF	.647064	.268560	2.409	.01598	-106.20	310.58
REV	.534531E-02	.973428E-02	.549	.58292	-52.618	226.18
REI	-.610843E-02	.971996E-02	-.628	.52971	-52.771	226.11
PRC	-.266480E-02	.725982E-02	-.367	.71357	-5.9979	9.3286
PA	-.769911E-03	.260081E-02	-.296	.76721	22.533	17.901
FO	.146413	.293570	.499	.61797	.90560	.24419
GDP	-.628524	.271774	-2.313	.02074	-53.257	225.99
MIN	-4.45673	2.96548	-1.503	.13287	-53.195	226.00
GDI	-1.04594	.913733	-1.145	.25234	-26.412	162.07
MAN	3.80996	2.79340	1.364	.17259	-53.053	226.04
AG	1.04419	.913727	1.143	.25313	-26.530	162.05
CNE	-.129175E-10	.208724E-10	-.619	.53599	-.67001E+08	.17231E+10
CPE	-.489103	.975426	-.501	.61607	.45613	.28538
GT	-.105656E-01	.188079E-01	-.562	.57428	4.1600	2.7804
EY	.483234E-01	.127346	.379	.70434	.17333	.38108
TT	-.135378E-01	.121338E-01	-1.116	.26455	11.907	8.1873
CD	-.656062E-01	.523483	-.125	.90027	.52000	.50296
ONE	-.316367	.943128	-.335	.73729	1.0000	.00000
	.283305	.252467E-01	11.221	.00000		

Initial Regression with Company Dummy Variables

Limited Dependent Variable Model - CENSORED Regression
Threshold Values -- Variable Constant
Lower ONE -1.000
Upper ONE 1.000
(Limit = variable times constant; **** = - or + infinity)

<< Least Squares Regression >>

Dependent Variable	X43	Number of Observations	75
Mean of Dep. Var.	-79.874896	Std. Dev. of Dep. Var.	272.860562
Std. Error of Regr.	172.060290	Sum of Sqrd. Residuals	1657865.621235
R - squared	.699090	Adjusted R - Squared	.602369

Variable	Coefficient	Std. Error	T-ratio	Prob|t|≥x	Mean of X	Std.D.of X
INF	-35.2890	156.652	-.225	.82177	-106.20	310.58
REV	1.61336	5.89781	.274	.78443	-52.618	226.18
REI	-1.67784	5.88853	-.285	.77569	-52.771	226.11
PRC	-2.76542	4.41634	-.626	.53120	-5.9979	9.3286
PA	1.44003	1.86177	.773	.43924	22.533	17.901
FO	99.6531	167.713	.594	.55239	.90560	.24419
GDP	36.2277	156.669	.231	.81713	-53.257	225.99
MIN	-232.698	1805.84	-.129	.89747	-53.195	226.00
GDI	-235.886	526.792	-.448	.65431	-26.412	162.07
MAN	268.082	1701.95	.158	.87484	-53.053	226.04
AG	235.880	526.783	.448	.65432	-26.530	162.05
CNE	-.396098E-08	.125902E-07	-.315	.75306	-.67001E+08	.17231E+10
CPE	-482.057	579.222	-.832	.40527	.45613	.28538
GT	-12.4680	11.0536	-1.128	.25934	4.1600	2.7804
EY	-3.13704	75.2789	-.042	.96676	.17333	.38108
TT	7.69986	7.21078	1.068	.28560	11.907	8.1873
CMD1	-285.270	320.533	-.890	.37347	.52000	.50296
CMD2	30.3154	78.1614	.388	.69812	.32000	.46962
ONE	149.645	543.508	.275	.78306	1.0000	.00000

Method=NEWTON; Maximum iterations = 25

Convergence criteria:	Gradient = .1000000E-01				
	Function = .1000000E-01				
	Parameters= .1000000E-01				
Starting values:	-.2051	.9377E-02	-.9751E-02	-.1607E-01	.8369E-02
	.5792	.2106	-1.352	-1.371	1.558
	1.371	-.2302E-10	-2.802	-.7246E-01	-.1823E-01
	.4475E-01	-1.658	.1762	.8697	.5812E-02

```
==> NEWTON Iterations

Iteration  1     Function    407.3543
Param   -.205      .938E-02 -.975E-02 -.161E-01  .837E-02  .579      .211
        -1.35     -1.37      1.56      1.37     -.230E-10 -2.80     -.725E-01
        -.182E-01  .448E-01 -1.66      .176      .870      .581E-02
Gradnt  -78.8     -589.     -599.      12.2     -42.7     -9.73     -.777E-01
        -76.4      745.     -77.8      746.     -.857E+09 -2.45     -77.2
         .823     -112.     -9.14     -.362     -9.73     -.114E+05

Iteration  2     Function    357.5507
Param    .225     -.209E-02  .209E-02 -.747E-03  .376E-03  .153E-01 -.218
        -1.80     -.539      1.58      .538     -.775E-11 -.366     -.154E-01
        -.362E-01 -.894E-03 -.141      .487E-02  .516E-01  .116E-01
Gradnt   23.1      .476      .169     -.207      .714E-01  .200     -.529E-01
         23.2      45.1      23.2      45.1      .358E+08  .477E-01  1.47
         .219E-01  .416      .200      .335E-04  .200     -.568E+04

Iteration  3     Function    311.8413
Param    .214     -.227E-02  .227E-02 -.133E-02  .407E-03  .339E-01 -.205
        -2.12     -.680      1.91      .679     -.966E-11 -.488     -.169E-01
        -.319E-01  .148E-02 -.214      .401E-02  .711E-01  .232E-01
Gradnt  -.592E-03 -.153E-01 -.159E-01 -.113E-03  .116E-02  .275E-03 -.633E-01
         .628E-01  .870E-01  .628E-01  .869E-01  .513E+05  .888E-04  .179E-02
         .242E-04 -.914E-03  .227E-03  .315E-04  .275E-03 -.284E+04

Iteration  4     Function    266.1849
Param    .228     -.213E-02  .212E-02 -.138E-02  .387E-03  .368E-01 -.217
        -2.21     -.698      1.98      .697     -.987E-11 -.494     -.170E-01
        -.304E-01  .113E-02 -.213      .427E-02  .618E-01  .465E-01
Gradnt  -.480E-01 -.161E-01 -.163E-01 -.160E-03  .122E-02  .145E-03 -.661E-01
         .181E-01  .196E-01  .181E-01  .196E-01  .103E+05  .593E-04  .104E-02
         .144E-05  .354E-03  .953E-04  .332E-04  .145E-03 -.142E+04

Iteration  5     Function    220.6308
Param    .254     -.185E-02  .180E-02 -.147E-02  .349E-03  .427E-01 -.242
        -2.38     -.734      2.12      .733     -.103E-10 -.505     -.171E-01
        -.274E-01  .415E-03 -.209      .480E-02  .434E-01  .928E-01
Gradnt   .551E-03 -.168E-01 -.175E-01 -.739E-03  .735E-03  .380E-03 -.718E-01
         .724E-01  .783E-01  .725E-01  .782E-01  .409E+05  .122E-03  .341E-02
         .579E-05  .113E-02  .326E-03  .361E-04  .380E-03 -708.

Iteration  6     Function    175.3137
Param    .308     -.128E-02  .116E-02 -.165E-02  .274E-03  .544E-01 -.293
        -2.71     -.805      2.41      .804     -.111E-10 -.529     -.173E-01
        -.214E-01 -.997E-03 -.203      .590E-02  .728E-02  .185
Gradnt   .199     -.170E-01 -.195E-01 -.294E-02 -.143E-02  .126E-02 -.832E-01
         .282      .305      .282      .305      .158E+06  .353E-03  .124E-01
         .228E-04  .386E-02  .119E-02  .420E-04  .126E-02 -353.
```

```
Iteration  7     Function    130.5989
Param     .413      -.155E-03 -.107E-03 -.202E-02  .130E-03  .777E-01 -.396
         -3.39      -.948      2.97       .947     -.128E-10 -.577     -.178E-01
         -.982E-02 -.377E-02 -.191       .819E-02 -.630E-01  .368
Gradnt    .955      -.131E-01 -.226E-01 -.108E-01 -.102E-01  .433E-02 -.106
         1.06       1.15       1.06       1.15      .580E+06  .116E-02  .442E-01
         .884E-04   .118E-01   .425E-02   .537E-04  .433E-02 -175.

Iteration  8     Function    87.57792
Param     .620       .205E-02 -.259E-02 -.278E-02 -.139E-03  .123      -.598
         -4.71      -1.23       4.09       1.23     -.161E-10 -.679     -.190E-01
          .123E-01 -.911E-02 -.173       .130E-01 -.196      .725
Gradnt   3.54        .704E-02 -.264E-01 -.353E-01 -.423E-01  .135E-01 -.151
         3.70       4.03       3.70       4.02      .193E+07  .361E-02  .141
         .327E-03   .232E-01   .134E-01   .768E-04  .135E-01 -85.4

Iteration  9     Function    49.57072
Param    1.00        .613E-02 -.718E-02 -.426E-02 -.598E-03  .208      -.975
         -7.17      -1.78       6.17       1.78     -.226E-10 -.890     -.220E-01
          .515E-01 -.187E-01 -.153       .227E-01 -.428      1.38
Gradnt   10.3        .670E-01 -.313E-01 -.877E-01 -.136      .312E-01 -.235
         10.5       11.6       10.5       11.6      .501E+07  .856E-02  .342
         .105E-02  -.234E-01   .310E-01   .120E-03  .312E-01 -39.2

Iteration 10     Function    24.39809
Param    1.59        .124E-01 -.142E-01 -.669E-02 -.124E-02  .339      -1.56
         -11.0      -2.66       9.43       2.65     -.330E-10 -1.26     -.282E-01
          .108      -.329E-01 -.149       .388E-01 -.759      2.39
Gradnt   17.2        .122      -.522E-01 -.119      -.256      .364E-01 -.367
         17.6       19.9       17.6       19.9      .730E+07  .107E-01  .439
         .225E-02  -.242       .361E-01   .188E-03  .364E-01 -14.5

Iteration 11     Function    17.07245
Param    2.13        .178E-01 -.203E-01 -.898E-02 -.178E-02  .456      -2.07
         -14.5      -3.48       12.4       3.47     -.429E-10 -1.63     -.350E-01
          .156      -.452E-01 -.166       .536E-01 -1.04      3.28
Gradnt   8.33       -.910E-02 -.103      -.473E-01 -.137      .114E-01 -.489
         8.83       10.4       8.83       10.4      .320E+07  .397E-02  .161
         .156E-02  -.218       .110E-01   .248E-03  .114E-01 -2.74

Iteration 12     Function    16.70931
Param    2.28        .193E-01 -.220E-01 -.963E-02 -.193E-02  .490      -2.21
         -15.6      -3.72       13.3       3.71     -.457E-10 -1.74     -.372E-01
          .169      -.486E-01 -.175       .576E-01 -1.11      3.53
Gradnt  -.270E-01  -.123      -.129      -.239E-02  .250E-02  .105E-02 -.525
          .498       .611       .499       .611      .169E+06  .498E-03  .103E-01
         .112E-03  -.128E-01   .653E-03   .263E-03  .105E-02 -.107
** B-vector has converged.
```

Maximum Likelihood Estimates

Log-Likelihood..... -16.709

Variable	Coefficient	Std. Error	T-ratio	Prob|t|≥x	Mean of X	Std.D.of X
INF	.645858	.268746	2.403	.01625	-106.20	310.58
REV	.547817E-02	.979561E-02	.559	.57599	-52.618	226.18
REI	-.623655E-02	.977706E-02	-.638	.52355	-52.771	226.11
PRC	-.272883E-02	.727923E-02	-.375	.70775	-5.9979	9.3286
PA	-.547377E-03	.318481E-02	-.172	.86354	22.533	17.901
FO	.138755	.300318	.462	.64406	.90560	.24419
GDP	-.627405	.271954	-2.307	.02105	-53.257	225.99
MIN	-4.41259	2.98783	-1.477	.13972	-53.195	226.00
GDI	-1.05410	.916243	-1.150	.24996	-26.412	162.07
MAN	3.76703	2.81585	1.338	.18096	-53.053	226.04
AG	1.05234	.916237	1.149	.25074	-26.530	162.05
CNE	-.129596E-10	.208759E-10	-.621	.53474	-.67001E+08	.17231E+10
CPE	-.494044	.976310	-.506	.61283	.45613	.28538
GT	-.105421E-01	.188094E-01	-.560	.57516	4.1600	2.7804
EY	.477446E-01	.127440	.375	.70792	.17333	.38108
TT	-.137716E-01	.122868E-01	-1.121	.26235	11.907	8.1873
CMD1	-.495683E-01	.540003	-.092	.92686	.52000	.50296
CMD2	.163249E-01	.134831	.121	.90363	.32000	.46962
ONE	-.315479	.943187	-.334	.73802	1.0000	.00000
	.283314	.252491E-01	11.221	.00000		

Final Regression

Limited Dependent Variable Model - CENSORED Regression
Threshold Values -- Variable Constant
Lower ONE -1.000
Upper ONE 1.000
(Limit = variable times constant; **** = - or + infinity)

<< Least Squares Regression >>

Dependent Variable	X43	Number of Observations	75
Mean of Dep. Var.	-79.874896	Std. Dev. of Dep. Var.	272.860562
Std. Error of Regr.	166.727058	Sum of Sqrd. Residuals	1918055.924460
R - squared	.651865	Adjusted R - Squared	.626638

Variable	Coefficient	Std. Error	T-ratio	Prob|t|≥x	Mean of X	Std.D.of X
INF	44.7279	58.4431	.765	.44408	-106.20	310.58
REI	-.348899E-01	.886587E-01	-.394	.69393	-52.771	226.11
GDP	-43.7672	58.4624	-.749	.45407	-53.257	225.99
MIN	-44.7737	58.4640	-.766	.44377	-53.195	226.00
AG	.106174E-02	.166914	.006	.99492	-26.530	162.05
ONE	-44.3107	27.1530	-1.632	.10270	1.0000	.00000

****

Method=NEWTON; Maximum iterations = 25
Convergence criteria: Gradient = .1000000E-01
Function = .1000000E-01
Parameters= .1000000E-01
Starting values: .2683 -.2093E-03 -.2625 -.2685 .6368E-05
-.2658 .5998E-02

==> NEWTON Iterations

Iteration 1	Function	402.6892					
Param	.268	-.209E-03	-.263	-.269	.637E-05	-.266	.600E-02
Gradnt	-3.54	146.	-.315	-.698	796.	-11.0	-.110E+05
Iteration 2	Function	355.5808					
Param	.168	-.630E-04	-.161	-.168	-.984E-03	-.625E-01	.120E-01
Gradnt	-.424	-.108E-01	-.596E-01	-.363	27.6	.948E-02	-.550E+04
Iteration 3	Function	309.8807					
Param	.171	-.698E-04	-.162	-.171	-.104E-02	-.634E-01	.240E-01
Gradnt	-.805E-01	-.157E-01	-.630E-01	-.174E-01	.210E-01	.101E-03	-.275E+04

```
 Iteration  4     Function    264.2324
 Param     .177     -.830E-04 -.166     -.176     -.107E-02 -.648E-01  .479E-01
 Gradnt  -.499E-01 -.164E-01 -.662E-01  .163E-01  .176E-01  .133E-03 -.137E+04

 Iteration  5     Function    218.6967
 Param     .188     -.110E-03 -.175     -.187     -.114E-02 -.676E-01  .958E-01
 Gradnt  -.851E-02 -.177E-01 -.725E-01  .642E-01  .695E-01  .334E-03 -686.

 Iteration  6     Function    173.4247
 Param     .209     -.162E-03 -.194     -.209     -.127E-02 -.731E-01  .191
 Gradnt    .163     -.201E-01 -.854E-01  .249      .270      .108E-02 -342.

 Iteration  7     Function    128.8317
 Param     .253     -.268E-03 -.235     -.252     -.153E-02 -.841E-01  .380
 Gradnt    .823     -.240E-01 -.111      .936      1.02      .368E-02 -169.

 Iteration  8     Function    86.17083
 Param     .339     -.473E-03 -.316     -.338     -.204E-02 -.106      .746
 Gradnt   3.07      -.292E-01 -.162      3.24      3.54      .113E-01 -82.3

 Iteration  9     Function    49.21063
 Param     .501     -.849E-03 -.472     -.500     -.298E-02 -.149      1.41
 Gradnt   8.76      -.371E-01 -.258      9.04      9.99      .254E-01 -37.2

 Iteration 10     Function    26.21916
 Param     .752     -.140E-02 -.711     -.750     -.438E-02 -.218      2.39
 Gradnt   13.9      -.646E-01 -.405      14.3      16.2      .275E-01 -13.1

 Iteration 11     Function    20.49493
 Param     .963     -.185E-02 -.908     -.960     -.552E-02 -.277      3.17
 Gradnt   5.59      -.117     -.528      6.13      7.21      .745E-02 -2.17

 Iteration 12     Function    20.28250
 Param    1.01      -.196E-02 -.946     -1.01     -.579E-02 -.292      3.35
 Gradnt   -.301     -.138     -.557      .256      .310      .779E-03 -.639E-01

 Iteration 13     Function    20.27455
 Param    1.02      -.196E-02 -.935     -1.01     -.580E-02 -.293      3.36
 Gradnt   -.556     -.139     -.556      .338E-03  .415E-03  .561E-03  .500E-03
** Function has converged.
```

Maximum Likelihood Estimates

Log-Likelihood..... -20.275

Variable	Coefficient	Std. Error	T-ratio	Prob|t|≥x	Mean of X	Std.D.of X
INF	.302857	.105687	2.866	.00416	-106.20	310.58
REI	-.583214E-03	.178229E-03	-3.272	.00107	-52.771	226.11
GDP	-.278192	.114459	-2.431	.01508	-53.257	225.99
MIN	-.301934	.105725	-2.856	.00429	-53.195	226.00
AG	-.172641E-02	.323975E-03	-5.329	.00000	-26.530	162.05
ONE	-.873141E-01	.490016E-01	-1.782	.07477	1.0000	.00000
	.297661	.264863E-01	11.238	.00000		

APPENDIX C

EFFECTIVE TAX RATE FORECAST

"Forecast" Data Used to Calculate Effective Tax Rate

YEAR	INF	REI	GDP	MIN	AG
1	0.50	0.25	0.010	0.120	0.120
2	0.50	0.25	0.010	0.121	0.116
3	0.50	0.25	0.010	0.121	0.113
4	0.50	0.25	0.010	0.122	0.110
5	0.50	0.25	0.010	0.122	0.106
6	0.50	0.25	0.010	0.123	0.103
7	0.50	0.25	0.010	0.124	0.104
8	0.50	0.25	0.010	0.124	0.104
9	0.50	0.25	0.010	0.125	0.105
10	0.50	0.25	0.010	0.124	0.105
11	0.40	0.25	0.010	0.123	0.106
12	0.40	0.25	0.015	0.121	0.106
13	0.40	0.25	0.015	0.120	0.107
14	0.40	0.25	0.015	0.119	0.107
15	0.40	0.25	0.015	0.118	0.108
16	0.40	0.25	0.015	0.113	0.108
17	0.40	0.25	0.015	0.108	0.109
18	0.40	0.25	0.015	0.104	0.109
19	0.40	0.25	0.015	0.100	0.110
20	0.40	0.25	0.015	0.096	0.111
21	0.40	0.25	0.015	0.092	0.111
22	0.25	0.25	0.015	0.088	0.112
23	0.25	0.25	0.015	0.085	0.112
24	0.25	0.25	0.015	0.085	0.112
25	0.25	0.25	0.015	0.085	0.112
26	0.25	0.25	0.015	0.085	0.112
27	0.25	0.25	0.015	0.085	0.112
28	0.25	0.25	0.015	0.085	0.112
29	0.25	0.25	0.015	0.085	0.112
30	0.25	0.25	0.015	0.085	0.112
31	0.25	0.25	0.015	0.085	0.112
32	0.25	0.25	0.015	0.085	0.112
33	0.25	0.25	0.015	0.085	0.112
34	0.25	0.25	0.015	0.085	0.112
35	0.25	0.25	0.015	0.085	0.112
36	0.25	0.25	0.015	0.085	0.112
37	0.25	0.25	0.015	0.085	0.112
38	0.25	0.25	0.015	0.085	0.112
39	0.25	0.25	0.015	0.085	0.112
40	0.25	0.25	0.015	0.085	0.112

APPENDIX D

OPTIMAL CONTROL MODEL DATA

Varying Tax Rate Optimal Control Model Data

YEAR	$1/(1+r)^t$	Price $/lb	λ	q_t/R_t
1	1.0000	1.00	0.3029	0.2749
2	0.8696	1.02	0.2593	0.2794
3	0.7561	1.04	0.2218	0.2837
4	0.6575	1.06	0.1895	0.2877
5	0.5718	1.08	0.1620	0.2909
6	0.4972	1.10	0.1385	0.2936
7	0.4323	1.13	0.1187	0.2943
8	0.3759	1.15	0.1023	0.2903
9	0.3269	1.17	0.0890	0.2815
10	0.2843	1.20	0.0788	0.2598
11	0.2472	1.22	0.0716	0.2641
12	0.2149	1.24	0.0651	0.2687
13	0.1869	1.27	0.0590	0.2739
14	0.1625	1.29	0.0535	0.2799
15	0.1413	1.32	0.0483	0.2859
16	0.1229	1.35	0.0435	0.2931
17	0.1069	1.37	0.0391	0.2997
18	0.0929	1.40	0.0350	0.3050
19	0.0808	1.43	0.0314	0.3099
20	0.0703	1.46	0.0280	0.3139
21	0.0611	1.49	0.0250	0.3164
22	0.0531	1.52	0.0224	0.3178
23	0.0462	1.55	0.0201	0.3172
24	0.0402	1.58	0.0181	0.3134
25	0.0349	1.61	0.0164	0.3042
26	0.0304	1.64	0.0150	0.3542
27	0.0264	1.67	0.0134	0.3587
28	0.0230	1.71	0.0119	0.3634
29	0.0200	1.74	0.0106	0.3684
30	0.0174	1.78	0.0095	0.3738
31	0.0151	1.81	0.0084	0.3803
32	0.0131	1.85	0.0075	0.3889
33	0.0114	1.88	0.0066	0.4021
34	0.0099	1.92	0.0058	0.4259
35	0.0086	1.96	0.0050	0.4768
36	0.0075	2.00	0.0042	0.6298
37	0.0065	2.04	0.0029	1.0199

Varying Tax Rate Optimal Control Model Data

YEAR	q_t (lbs.)	R_t (lbs.)
1	274,883	1,000,000
2	202,578	725,117
3	148,253	522,538
4	107,681	374,285
5	77,559	266,604
6	55,500	189,046
7	39,302	133,546
8	27,363	94,244
9	18,829	66,881
10	12,482	48,052
11	9,393	35,569
12	7,034	26,176
13	5,243	19,142
14	3,891	13,899
15	2,861	10,008
16	2,095	7,147
17	1,514	5,052
18	1,079	3,538
19	762	2,459
20	533	1,697
21	368	1,164
22	23	796
23	172	543
24	116	371
25	77	254
26	63	177
27	41	114
28	27	73
29	17	47
30	11	29
31	7	18
32	4	11
33	3	7
34	2	4
35	1	2
36	1	1
37	0	0

Constant Tax Rate Optimal Control Model Data

YEAR	$1/(1+r)^t$	Price $/lb	λ	q_t/R_t
1	1.0000	1.00	0.3404	0.2468
2	0.8696	1.02	0.3038	0.2501
3	0.7561	1.04	0.2712	0.2535
4	0.6575	1.06	0.2420	0.2568
5	0.5718	1.08	0.2160	0.2603
6	0.4972	1.10	0.1928	0.2637
7	0.4323	1.13	0.1720	0.2672
8	0.3759	1.15	0.1535	0.2707
9	0.3269	1.17	0.1370	0.2743
10	0.2843	1.20	0.1222	0.2779
11	0.2472	1.22	0.1090	0.2816
12	0.2149	1.24	0.0973	0.2853
13	0.1869	1.27	0.0868	0.2890
14	0.1625	1.29	0.0774	0.2928
15	0.1413	1.32	0.0690	0.2966
16	0.1229	1.35	0.0616	0.3004
17	0.1069	1.37	0.0549	0.3043
18	0.0929	1.40	0.0490	0.3083
19	0.0808	1.43	0.0437	0.3123
20	0.0703	1.46	0.0390	0.3163
21	0.0611	1.49	0.0347	0.3204
22	0.0531	1.52	0.0310	0.3245
23	0.0462	1.55	0.0276	0.3287
24	0.0402	1.58	0.0246	0.3330
25	0.0349	1.61	0.0220	0.3373
26	0.0304	1.64	0.0196	0.3417
27	0.0264	1.67	0.0174	0.3463
28	0.0230	1.71	0.0155	0.3511
29	0.0200	1.74	0.0138	0.3563
30	0.0174	1.78	0.0123	0.3622
31	0.0151	1.81	0.0110	0.3694
32	0.0131	1.85	0.0097	0.3788
33	0.0114	1.88	0.0086	0.3925
34	0.0099	1.92	0.0075	0.4151
35	0.0086	1.96	0.0065	0.4566
36	0.0075	2.00	0.0054	0.5476
37	0.0065	2.04	0.0041	1.0199

Constant Tax Rate Optimal Control Model Data

YEAR	q_t (lbs.)	R_t (lbs.)
1	246,821	1,000,000
2	188,389	753,179
3	143,156	564,790
4	108,295	421,634
5	81,551	313,339
6	61,127	231,788
7	45,603	170,661
8	33,859	125,059
9	25,018	91,200
10	18,394	66,182
11	13,456	47,788
12	9,794	34,322
13	7,092	24,538
14	5,108	17,447
15	3,660	12,339
16	2,608	8,679
17	1,848	6,071
18	1,302	4,224
19	912	2,922
20	636	2,009
21	440	1,374
22	303	934
23	207	631
24	141	423
25	95	282
26	64	187
27	43	123
28	28	81
29	19	52
30	12	34
31	8	21
32	5	14
33	3	8
34	2	5
35	1	3
36	1	2
37	1	1

APPENDIX E

ANNUAL CASH FLOWS

Annual Cash Flows From the Optimal Depletion Paths

YEAR	CASH FLOW Varying ETR $	CASH FLOW Constant ETR $
1	114,810	111,540
2	72,147	75,671
3	44,957	51,110
4	27,766	34,365
5	16,988	23,001
6	10,332	15,324
7	6,219	10,161
8	3,682	6,705
9	2,170	4,403
10	1,238	2,877
11	845	1,871
12	573	1,210
13	387	779
14	260	499
15	172	317
16	114	201
17	74	127
18	47	79
19	30	49
20	18	31
21	11	19
22	7	12
23	4	7
24	3	4
25	2	3
26	1	2
27	1	1
28	<1	1
29	<1	<1
30	<1	<1
31	<1	<1
32	<1	<1
33	<1	<1
34	<1	<1
35	<1	<1
36	0	<1
37	0	0
Total	302,857	340,367